Volume 63 | December, 1949 | $4.00 a Year
Number 4 | Pages 315-430 | $1.25 a Number

# Journal of the New England Water Works Association

ISSUED QUARTERLY

*Published by*
THE NEW ENGLAND WATER WORKS ASSOCIATION
204 Tremont Building, Boston, Massachusetts

Entered as second-class matter September 23, 1903, at the Post Office at Boston, Mass., under Act of Congress of March 3, 1879
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## 1949 - 1950

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THE Association was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of 900 men. Its membership is divided into six classes, viz.:

*A Member* shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

*An Honorary Member* shall be a person of acknowledged eminence in some branch of water supply or of engineering.

*A Junior* shall be not less than eighteen years nor more than twenty-five years of age, a student or connected with water supply work.

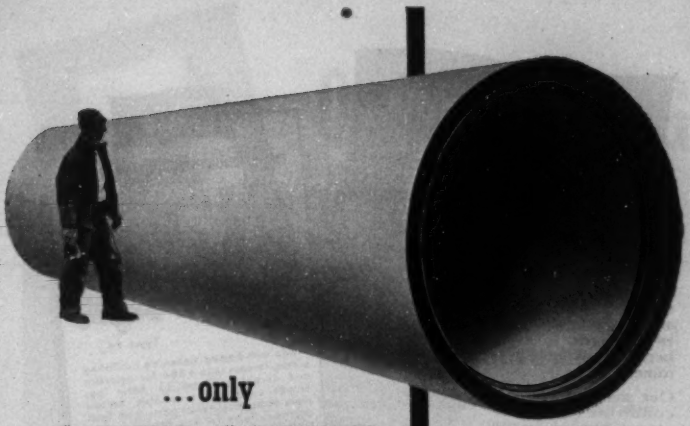
*An Associate* shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

*A Corporate Member* shall be either a Water Board, Commission, Company or Municipal Corporation.

The initiation fees and annual dues are as follows:

| | *Initiation Fees* | *Annual Dues* |
|---|---|---|
| Members | $ 5.00 | $ 6.00 |
| Juniors | 1.00 | 3.00 |
| Associates | 10.00 | 20.00 |
| Corporate Members | 10.00 | 10.00 |

This Association has at least eight regular meetings each year, of which five are held in Boston, one in northern New England, one in southern New England, and one, the annual convention, held in September on such date as the Executive Committee may designate.



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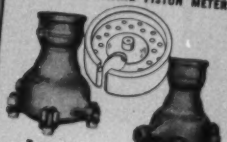
*This*

**EMPIRE OSCILLATING PISTON METERS**



Type 12 Type 14

Made with Empire balanced oscillating piston, famous since 1884 for accuracy and durability. Type 12 meter has bronze case with breakable bottom plate to protect interior parts from frost damage. Type 14 is a bronze bottom plate model for warm climates. Sizes ⅝-in., ¾-in., 1-in.

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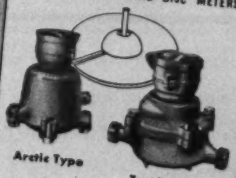

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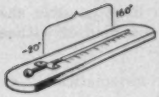
The highest quality measuring instruments of this type. Durably constructed to give years of uninterrupted service. Arctic type is protected against damage from freezing by breakable frost bottom. Tropic type has split case, all bronze housing. Sizes ⅝-in., ¾-in., 1-in.

# PITTSBURGH-EMPIRE *Water Meters*

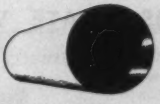
# 5 OUTSTANDING ADVANTAGES

## of Barrett* protective coatings for the Water Industries

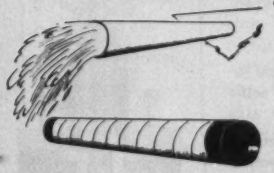



1. **They are unaffected by Wide Temperature Changes** Barrett* Waterworks Enamels neither flow nor sag in temperatures as high as 160°F. Nor do they crack in temperatures as low as 20° below zero.

2. **They are Flexible and Ductile** They possess sufficient elasticity to withstand "breathing" of the pipe as pressures fluctuate, and out-of-round deflection when the pipe is being installed or by the weight of the backfill when the pipe is out of service.



3. **They prevent Tuberculation** When used to line the inside of a pipe, Barrett Waterworks Enamels prevent tuberculation, thus enabling the pipe to maintain its original capacity.



4. **They increase the Coefficient of Flow** After lining with Barrett Waterworks Enamels, Hazen-Williams "C" averages 150. Initial power installation is less expensive, and owing to the prevention of tuberculation, the cost of power does not increase after years of service.

5. **They assure Firm Bond** Barrett Waterworks Enamels assure a firmer bond at the interfaces of steel, primer, and enamel.

**BARRETT WATERWORKS ENAMELS** are manufactured specifically to meet the requirements of the water industries. Long and extensive service in the field has proved their worth. The Barrett organization will be glad to advise on materials and on application procedure, and to consult with you on any pipe-coating problem.

Barrett*

**THE BARRETT DIVISION**
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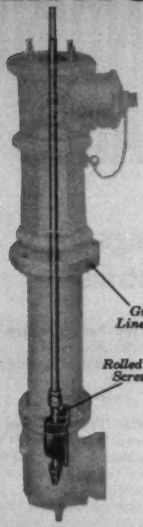



To inspect or service a Ludlow Slide Gate Hydrant you'll need a wrench — that's all. Just take off the top of the hydrant and lift out the stem, *without unscrewing anything below ground.* The entire mechanism, including the gate, bronze wedge nut and drip assembly is attached to the stem.

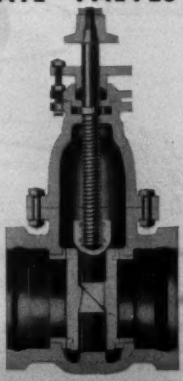
## LUDLOW FIRE HYDRANTS

Shown here is the distinctive Ludlow List No. 90, now serving in thousands of cities and towns. It employs the famous Ludlow Slide Gate principle, and (in addition to easy servicing) offers the following advantages:

- *Quick Water* with least possible shock and pressure loss. Proper shut-off without water hammer.
- *Proper Drainage*, automatically, at lowest point when closed.
- *No Flooding.* Wedge-locked when closed. Accidental breaking will not cause flood. Hydrant head breaks at ground line — is easily replaced without excavation.

## LUDLOW AWWA DOUBLE DISC GATE VALVES

The parallel seated, double wedge type slide gate valve, developed and perfected by Ludlow, provides a number of essential benefits.



- *Smooth, Positive Operation.* Gates positioned directly opposite ports before wedging, and entirely unwedged before being raised.
- *Positive Closure.* Even after years of service in the open position; flexible-action gates self-adjusting to seats.
- *Simplicity!* Only 2 parts in the wedging mechanism! These are extra heavy with ample reserve strength and wear resistance for years of constant service.

Made in sizes from 2" to 72", N.R.S. and O.S.&Y. with all types of connections. 95-S

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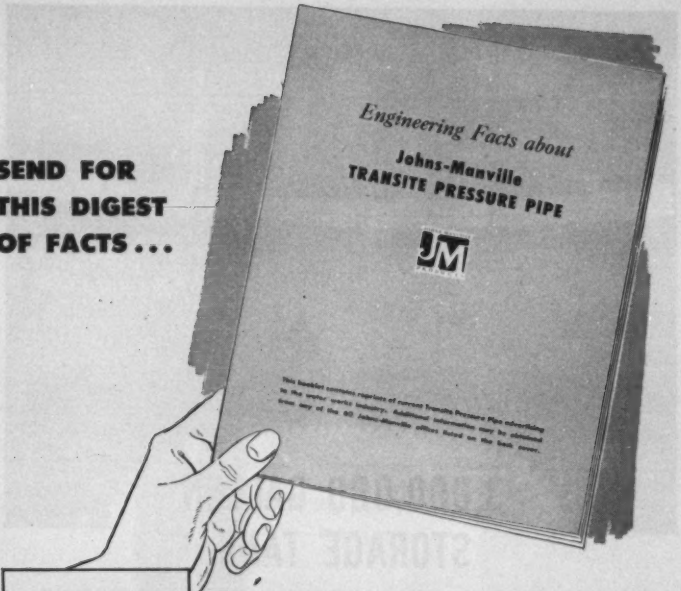
The LUDLOW VALVE MFG·CO·INC·TROY·N·Y·

SINCE 1866

**SEND FOR THIS DIGEST OF FACTS...**




**SOME OF THE SUBJECTS COVERED IN THIS BOOK:**

- Installation Economies
- Carrying Capacity
- The Simplex Coupling
- Making Service Connections
- Resistance to Corrosion —an Index of Long Life
- Case Histories
- Dimensions —and other useful data

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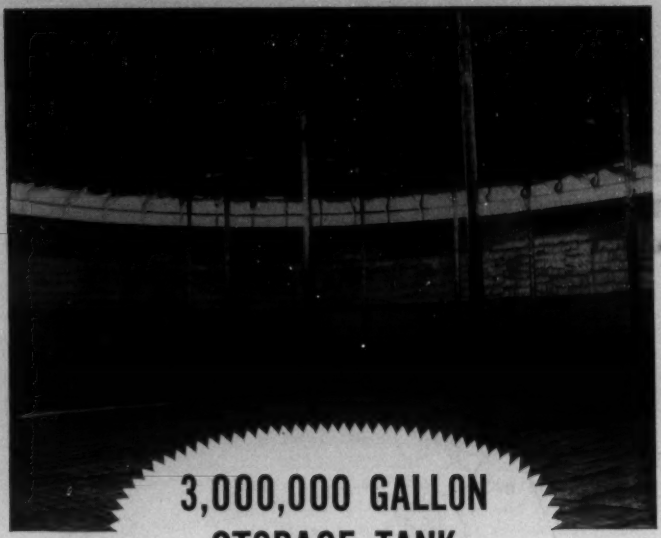
A compilation of the advertisements in our current "Engineering Facts" series, it presents concise, factual information about Transite's many economic and engineering advantages . . . includes informative case histories that give a new perspective on how this asbestos-cement pipe meets today's requirements for a modern, efficient water carrier.

In addition, it contains dimensions and other useful data about Transite Pipe which you'll want for your files. A copy is yours for the asking. Write Johns-Manville, Box 290, New York 16, N. Y.

**Transite is a registered Johns-Manville trade mark*

**Johns-Manville TRANSITE PRESSURE PIPE**



# 3,000,000 GALLON STORAGE TANK

## *protected by KOPPERS BITUMASTIC*

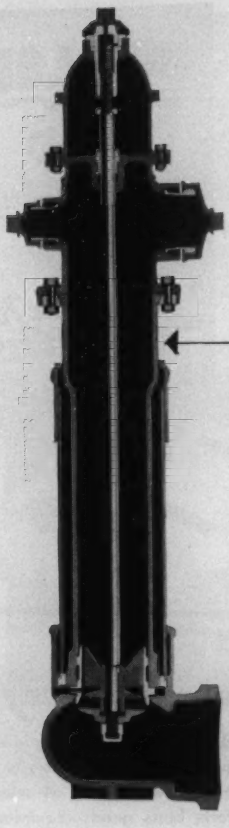
● A thick, tough coating of Koppers Bitumastic® 70-B Enamel keeps corrosion completely under control inside this 3,000,000 gallon water storage tank, property of the Marin Municipal Water District, San Rafael, Calif.

Applied to sidewalls, bottom, ladders, piping, and support columns, the Bitumastic Enamel forms a lasting barrier that keeps the water from reaching the underlying metal. Age won't change the effectiveness of the Bitumastic coating.

Koppers Contract Department will furnish complete equipment, skilled workmen and competent supervision for the job of protecting your water and sewage systems with Koppers Bitumastic Enamel . . . hand-brushed on interiors of storage tanks, standpipes and steel reservoirs . . . machine-applied inside and out to steel water and sewer pipe. Submit your problems for recommendations and quotations.

KOPPERS **BITUMASTIC ENAMELS**

**KOPPERS COMPANY, INC., Dept. 1215T, Pittsburgh 19, Pa.**



# ACCESSIBILITY

A Mathews broken in a traffic accident can be restored WITHOUT EXCAVATING, because of the unique replaceable barrel, and with only a few minutes' interruption in service.

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**Made by R. D. Wood Company**

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Manufacturers of "Sand-Spun" Pipe (centrifugally cast in sand molds) and R. D. Wood Gate Valves.

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**Mathews Modernized Hydrants Set the Pace:** Easily maintained because simple in construction • All working parts contained in the replaceable barrel • Stuffing box cast integral with nozzle section • Head can be turned 360° • Replaceable head • Nozzle sections easily changed • Nozzle levels raised or lowered without excavating • Protection case of "Sand-Spun" cast iron for extra strength, toughness, elasticity • Operating thread only part to be lubricated • A modern barrel makes an old Mathews good as new

# YES...

## IT'S MEANT FOR YOU!!

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DEPENDABLE SINCE 1857 FULLY WARRANTED OUR 91st YEAR

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MAIN OFFICE AND FACTORY DECATUR, ILLINOIS
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*where performance counts . . . count on Centriline*

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A total of more than 68,000 feet of cast iron pipe has been cleaned and uniformly lined with dense cement mortar in this city. Pipe sizes were from 24" to 48". On the last job, the average speed of lining was better than 1,000 feet per day—resulting in minimum interruption in water distribution.

Cincinnati has found that Centrilining pays. It will establish and maintain a high coefficient, reduce pumping cost, stop all leakage and terminate deterioration. Consult Centriline's experienced hydraulic engineers. A 28-page illustrated bulletin is also available on request.

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**CEMENT MORTAR LININGS FOR WATER MAINS CENTRIFUGALLY APPLIED** in strict conformity with A. W. W. A. Specifications.

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*ANOTHER NEW Badger Chart, No. 696 (Practical floor plan for a large meter repair shop). Available without cost or obligation. WRITE today for this chart.*

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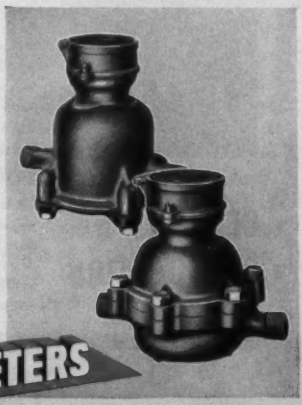
*You will find a Badger Meter size and type for every waterworks service. Shown here are Model SC-IOT (for warm climates), and Model A-IOT (for cold climates) . . . sizes ⅝" to 1¼" . . . other models in sizes up to 12". Write for complete information and prices.*



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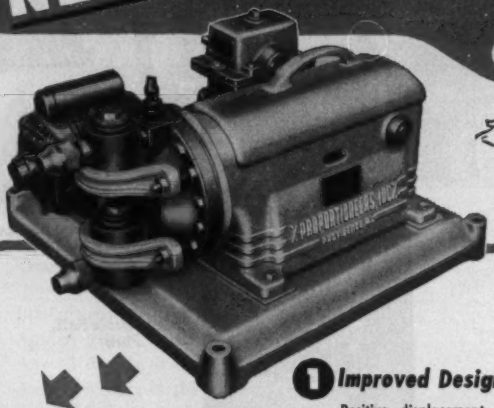
ACCURACY • LOW-COST MAINTENANCE • DURABILITY • SENSITIVENESS

# GOOD NEWS! A New Ferro-Feeder Improved 3 Ways



**%PROPORTIONEERS%** new Ferro-Feeder is the ideal proportioning pump for sludge conditioning . . . it's specially made to feed 35% to 40% solutions of ferric chloride or other corrosive liquids against pressures to 20 p.s.i. In design, construction, and operation, the Ferro-Feeder incorporates the experience gained in the manufacture of over 27,000 %Proportioneers% chemical feeders.

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Positive displacement for high accuracy • Large Capacity . . . one gallon per minute • Feeding rate adjustable while unit is operating.

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Soft rubber, whipcord reinforced diaphragm • Hard rubber check valves and reagent head • Long-lived Hastelloy "D" and other non-corrosive metals.

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Automatically feeds in proportion to variable flow • Delivers chemical to upper levels under pressure • Easily cross-connected to sewage pump and other equipment or direct chain driven from sludge elevator sprocket.

*Write today for complete information*

## % PROPORTIONEERS, INC. %

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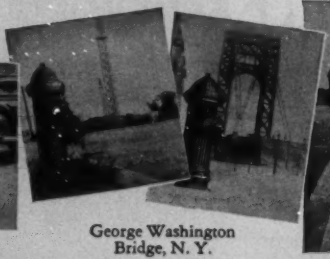
# Many are the reasons why Smith hydrants are used by America's leading cities!

Empire State Bldg., N. Y.



George Washington Bridge, N. Y.

Capitol Building, Wash., D. C.

Independence Hall, Phila.

**New York — Philadelphia — Washington — Baltimore — St. Louis — Providence and scores of other cities throughout the nation use SMITH hydrants — and not without good reason. A few of these reasons can easily be seen upon inspection of the hydrant section shown at the left.**

1. Working parts easily removed from top.
2. Frangible couplings for collision protection.
3. Maximum flow due to large stand pipe areas.
4. Tapered, frost-proof barrel
5. Compression-type valve.
6. Positive action drain—always closed when main valve is open.

31

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ESTABLISHED 1874

EAST ORANGE, NEW JERSEY

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New England Water Works Association
ORGANIZED 1882

VOL. LXIII DECEMBER, 1949 NO. 4

*This Association, as a body, is not responsible for the statements or opinions of any of its members*

# CASUAL OBSERVATIONS OF ENGLISH WATER-WORKS PRACTICE

BY E. SHERMAN CHASE*

[*Presented September 13, 1949.*]

MR. PRESIDENT and members of the New England Water Works Association:

The first part of my talk this afternoon is in effect the report of the Committee on Reciprocal Relations with the Institution of Water Engineers.

You may recall that there is an arrangement whereby every second year one society or the other exchanges a paper prepared by one of its members. For example, the Gordon Fair paper on "Hydraulic Investigation of Water Distribution Systems" was awarded recognition by the Institution in 1947 as our contribution to this reciprocal arrangement. The arrangement was made before the war but during the war was interrupted. We received this past year four papers from the Institution of Water Engineers, of which your Committee selected the one which seemed most worthy of recognition, taking into consideration its usefulness to our members and applicability to our problems. The paper selected was by Mr. C. A. Risbridger, of the Water Department of Birmingham, who was awarded a diploma engraved on parchment, similar to the certificates of membership in the Association. The wording on the diploma was as follows:

"This Diploma has been awarded to
CHARLES ARTHUR RISBRIDGER
of the Institution of Water Engineers of Great Britain
for his paper on
THE DESIGN AND CONSTRUCTION OF
PERRY BARR SERVICE RESERVOIR

*Chairman, Committee on Reciprocal Relations with the Institution of Water Engineers (England); Partner, Metcalf & Eddy, Statler Bldg., Boston 16, Mass.

published in the Journal of the Institution for 1947 and selected for its Merit for republication in the Journal of the New England Water Works Association.

"This Award is given also in Evidence of the High Regard held by the Association for the Institution and as a Pledge of Friendly Co-operation."

The diploma was signed by Mr. Knox as Secretary and by Mr. King as President.

I was in England in June and had the pleasure of presenting this diploma in person to Mr. Risbridger at the summer meeting of the Institution. The meeting was held in the resort town of Buxton, in the Midlands, not far from the industrial cities of Sheffield and Manchester. The conditions under which the meeting was held were somewhat similar to our meeting here at the Balsams, inasmuch as the town of Buxton is a watering place and not an industrial or commercial municipality.

The meetings of the Institution of Water Engineers are characterized by greater social activities, perhaps, and more excursions to water works of interest than are ours. The municipal corporations whose works are to be inspected are more liberal in the way they treat the members of the Institution than are our cities to members of the Association. The corporation of Sheffield gave two or three beautifully turned-out luncheons. The technical meetings were held in an auditorium in the Town Hall of Sheffield. The City Park Department had furnished flowers, palms and floral decorations for the stairways leading to the auditorium and for the assembly room where the papers were given.

On the excursions the corporations provided luncheons and teas at the works being inspected. In Sheffield a municipal caterer furnished the food and the equipment. We had one luncheon in the City Hall, which was separate from the Town Hall. The Town Hall is more of a social center. It is used to hold meetings and is the seat more of the government than it is of the administration. The City Hall provides offices for the different departments but, generally speaking, the Town Hall is the place where entertainments for visitors are given and where the Lord Mayor has his offices.

Incidentally, in Sheffield the Lord Mayor is a woman and yet she is addressed as "My Lord Mayor." Her daughter has been appointed as the Lady Mayoress. Ordinarily, when the Lord Mayor of an English city is selected, his wife is appointed as the Lady Mayoress. The Lord Mayors and the Lady Mayoresses of England seem to be more the official greeters for the City, like Grover Whalen in New York, rather than the administrative heads, like our Mayors. The Lord Mayor of Sheffield is evidently a woman of considerable ability and her understanding of water-works problems would put to shame some of our chief executives.

As your representative, I took part in some of the proceedings. I gave a discussion of Dr. Race's paper on "A Resumé of the History of Chlorination." You will remember that Dr. Race, when he was in Canada, did a lot with chlorine-ammonia treatment of water supplies and with the development of chloramine treatment. At the formal dinner, which is much more formal than our dinners, I responded to the toast to the visitors.

Toasts constitute quite a ceremony. The first toast is to the King after which, but not before, can you smoke. Then there may follow series of toasts, which give opportunity for those who are proposing toasts to be as interesting as lies within their capacity. The toasts are relatively short, as are the replies, and generally more interesting than the long after-dinner speeches to which we have to listen sometimes.

The excursions that I attended were to some of the filter plants connected with the Sheffield water works and to the impounding reservoirs of the Derwent Valley Water Board, which provide part of the water supply of Sheffield. Perhaps 25% of the Sheffield supply comes from a joint development of certain watersheds used to supply other municipalities and local boards in Yorkshire. Sheffield also develops independent supplies from some five other sources.

Pressure filters in England for municipal supplies are used much more than in this country. In the United States, rapid sand filters of the gravity type are used on municipal supplies and pressure filters are used largely in the case of industrial plants. One of the Sheffield supplies is filtered through three batteries of pressure filters, each group being manufactured by a different manufacturer of filters. One of these batteries is shown in Figure 1.

FIG. 1.—RIVELIN FILTERS, SHEFFIELD WATER BOARD.

I inquired in Sheffield as to whether they were continuing to recondition their water mains with cement lining, using the Tate process, and with the bitumin lining, using the Eric process. Mr. Wood, the Sheffield water engineer, said that they were continuing to use both processes, as they have been doing for quite a number of years.

One thing wherein English practice differs from ours is the use of much smaller mains than over here, and odd sizes as three-inch and seven-inch. Consequently, when supplies like that of Sheffield, which is normally quite corrosive, tuberculate the interior of these small mains, there occurs a serious loss in carrying capacity. Therefore the reconditioning of pipe lines is quite an important factor in the maintenance of a good many of the English water-works systems.

Sheffield has used open distribution reservoirs for storage of water after filtration, but apparently a program of covering the existing open ones is under way and future distribution reservoirs appear to be designed with covers (see Fig. 2). One thing that you will notice in Mr. Risbridger's paper is the use of massive concrete walls instead of thin reinforced walls. That is due to the continued shortage of steel in England.

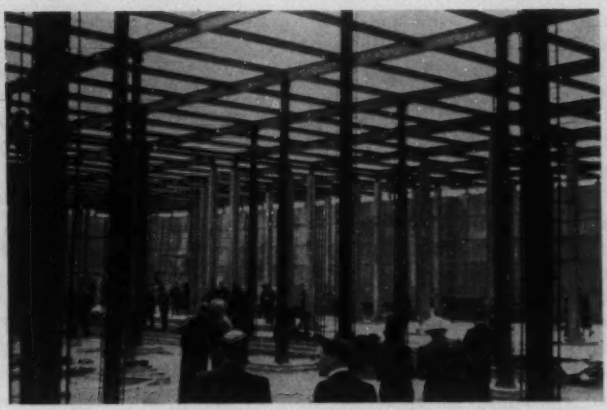


FIG. 2.—SERVICE RESERVOIR UNDER CONSTRUCTION, SHEFFIELD WATER BOARD.

Another factor which may be of significance in connection with the problem of getting steel for water-works purposes is the fact that, with the present socialist government, priorities for many construction materials apparently are much higher for the nationalized industries than they are for the non-nationalized industries. For example, gate valves can be secured on a much higher priority by the electric utilities in England than they can by the water utilities, because, you may assume, the electric industry is nationalized and the water-works industry is not.

Speaking of nationalization, I had my hair cut in Buxton and got to talking to the barber. Incidentally, you can get a haircut in England for a quarter and you can't do that over here. I said to the barber, "You are not nationalized yet?", and he replied, "No; I hope we never are, and if we are, I will pack up my kit and tramp around the country." He then told a story of a doctor and a woman who had come to the doctor for consultation. When the doctor started to interview the woman, she volunteered the information that this was the first time in her life that she had ever gone to a doctor. She

was a woman of perhaps 60 years of age. So the doctor said, "Have you never been sick?" "Well," she replied, "I have had colds now and then." "What did you do?" "I would take some hot whiskey and a couple of aspirin and go to bed." The doctor then inquired, "What is the trouble with you now?" "I have a cold coming on." "What do you want me to do?" "I want a prescription for some aspirin."

Now to get back to the Derwent Valley Water Board. This Water Board has developed three reservoirs on a watershed of about 60 sq mi. These reservoirs have a combined storage of about 12,000-13,000 mil gal (U. S.). Compensation water, amounting to roughly 0.4 mgd per square mile of drainage area, is let down for the use of the industries and for sanitation purposes below the lowest reservoir. This reservoir was built largely as a compensation reservoir and is a beautiful piece of work. The maximum depth is about 140 ft at the dam. The dam is an earth embankment with puddled clay core-wall (see Fig. 3). There are two spillways of the morning-glory type (see Fig. 4).

Considerable reforestation is being done on some watersheds. I saw the reforestation work on the Derwent Valley Water Board's sources and also on the Plymouth watershed in the south of England.

An interesting piece of anti-aircraft protection on reservoirs consisted of cables strung across some reservoirs, with vertical cables suspended at intervals from the catenary cables, so that aircraft, trying, say, to drop poison bombs, bacterial bombs, or what not into a reservoir, might get tangled up in those wires. I don't know what particular good it would do if they did get tangled up, as they would then drop in the reservoir and the reservoir would not be really protected.

In London I spent one day with Mr. Cronin, the Chief Engineer of the Metropolitan Water Board, looking over some of their works, but more particularly driving around London to see the effects of the bombing. West of London, near some of the reservoirs of the Metropolitan Water Board, slow sand filters are being built with a capacity of about 110 mgd (U. S.). I asked Mr. Cronin why they did not use rapid sand filters and he said that they found difficulty with the

FIG. 3.—DAM AT LADYBOWER RESERVOIR, DERWENT VALLEY WATER BOARD.

FIG. 4.—SPILLWAY OF LADYBOWER RESERVOIR, DERWENT VALLEY WATER BOARD.

treatment of stored Thames River water. About two-thirds of the London water supply comes from the Thames, downstream of Windsor. The river water is pumped into large storage reservoirs, which are big basins, scooped out of the level plain and formed by embankments of the excavated material around their perimeters. Due to the long storage period in the reservoirs, there develop growths of microorganisms. When the water is coagulated with alum, instead of the floc's sinking to the bottom as sediment or sludge, the combination of algae and alum floc rises and stays on the surface, causing much difficulty with rapid sand filtration. The Water Board, however, is going ahead with an experimental program, with a full-size pilot plant of 1-mgd capacity, to see what can be done with other methods of treatment besides slow sand filters. In some instances the sand filters are preceded by rapid sand filters used, without any coagulant, as sand strainers to take out the algae.

Within the last three years there has been developed what is called a micro-strainer—a cylindrical frame, covered with a stainless-steel woven-mesh cloth, backed up by a heavier, larger-mesh screen. The specially woven wire cloth has, as I remember, something like 76,000 apertures to the square inch, and I was told that water will not go through it unless capillary attraction is set up on the under side. The Water Board has carried on experiments for a year or so with a pilot plant of four of these screens, treating about 6 mgd of water. This pilot plant has been quite effective and it is planned to provide micro-filters ahead of the new slow sand filter now under construction.

Another interesting fact in connection with the London Water Works is that there are three or four old pumping engines, installed 80 to 100 or more years ago, which are still in condition to be operated if necessary. These engines are the type developed by Newcomen for pumping water from the tin mines of Cornwall.

For the first time I learned that the use of "horsepower" as a measure of the work done by a pump was developed by a chap by the name of Savery down in Devon, in the early part of the last century. He worked with Newcomen on the development of these Cornish pumping engines.

Those of you who have water boards that you have to convince of the appropriateness of the programs you would like to put into effect and have perhaps a half-dozen members, each one of whom you have to convince, ought to cheer up a bit when I tell you that the Metropolitan Water Board of London has 66 members. Imagine trying to convince 66 different men!

I asked Mr. Cronin about the effect of bombing on some of his reservoirs. There were a half-dozen or more of those large storage reservoirs, and apparently none was seriously damaged by the bombing. The large Queen Mary reservoir had a direct hit by a 500-lb high-explosive bomb on one of the embankments, but it landed above the high-water line, at a time when the reservoir had been drawn down 5 ft. Although a hole was blown in the embankment, the latter was not breached and, while they had some anxious moments, no serious results were brought about. Undoubtedly the reservoirs now contain a good many bombs which landed in the water.

You may remember that in December, 1940, I think it was, there was a terrific incendiary raid on London and a very large area of the old city of London was practically destroyed. One of the reasons why the damage was so great and the fire so difficult to control was the fact that the Thames was at low tide and the hundreds of mobile fire pumps which were available could not get water from the river.

In London the bombing did tremendous damage to the streets and water mains, but as I drove around the city I saw no evidence of damaged streets. An excellent job of fixing up the streets and repairing the mains has been done, although Mr. Cronin thinks that there may continue to be a substantial amount of leakage from the mains. Although the mains may not be actually ruptured, it may well be that joints were opened up and that a lot of water is still getting away. The water consumption has increased very materially, as compared with before the war. In view of some charts showing the effect of bombing on water consumption, as nearly as I could tell, every time there was a serious air raid the water consumption in the London area was increased about 25%.

Another thing that strikes an American as odd is that you never see a hydrant over there. All the hydrants are underground. Charles Sherman wrote a paper, which was published in the JOURNAL, tell-

ing about the invisible hydrants in the English and Continental water systems. The only hydrants I saw either in England or on the Continent were hydrants in the little village of Mürren, up in the Alps in Switzerland.

I have brought back a considerable amount of data with respect to some of the water works in England and, if any of you have questions that you would like to ask and you will write me, perhaps I can find the answers in those data. There is a lot of interesting work that has been done on the water-works systems in England, and detailed descriptions of some of these works are available in the Journals of the Institution of Water Engineers, in the library of the New England Water Works Association.

## References

1. "The Design and Construction of Perry Barr Service Reservoir". C. A. Risbridger, Journal Inst. Water Engineers, 1947, p. 337 (Reprinted in this issue of this JOURNAL, p. 325).
2. "Derwent Valley Water Board's Undertaking". Anon., Journal Inst. Water Engineers, 1949, p. 391.
3. "The Sheffield Water Undertaking". J. Noël Wood, Journal Inst. Water Engineers, 1949, p. 395.
4. "The Ladybower Reservoir". Harry Prescot Hill, Journal Inst. Water Engineers, 1949, p. 414.
5. "The Sources of Water Supply to the London Area". H. A. P. Hetherington, Journal Inst. Water Engineers, 1944, p. 125.
6. "Some Random Notes on Water Works Practice Abroad". Charles W. Sherman, Journal N.E.W.W.A., 1926, p. 297.

# THE DESIGN AND CONSTRUCTION OF PERRY BARR SERVICE RESERVOIR*

BY C. A. RISBRIDGER, B.Sc., M.I.C.E.

## FOREWORD

MANY accounts of the design and construction of service reservoirs have appeared as Papers read before professional Institutions and in the technical Press. Before submitting this Paper, therefore, the Author speculated at some length as to whether the work to be described embodied features of a sufficiently unusual character to justify its submission. He was finally assisted to an affirmative conclusion by a consideration of the fact that, the late war having caused a long interruption of the development programmes of most undertakings, many service reservoirs will, no doubt, be among the works to be undertaken as soon as possible, in an attempt to compensate for that interruption. Thus it may well be that the account here given, together with the discussion it is hoped to provoke, will at least be of interest to those who, in the interval, have inherited the responsibility for the design and construction of similar works.

The Author makes no apology for having enlarged here and there upon matters of detail, since he is of the opinion that it is upon the care and attention given to such details, both of design and in execution, that the success of a job very largely depends.

## INTRODUCTION

The distribution system of the City of Birmingham Water Department comprises five distinct zones of supply. The three highest zones are supplied by pumping, and together account for approximately one-third of the total supply.

The gravitational supply is divided into two zones, viz.: the

**At the Council House, Birmingham, Wednesday, 28th May, 1947.*

*Note*: This paper is reprinted from the Journal of the Institution of Water Engineers (London), vol. I, no. 4, July, 1947 (p. 337). The author was awarded the reciprocal diploma from the New England Water Works Association in June, 1949.

Middle Level and the Low Level, with a present approximate average daily demand of 20 million gallons and 8 million gallons respectively.

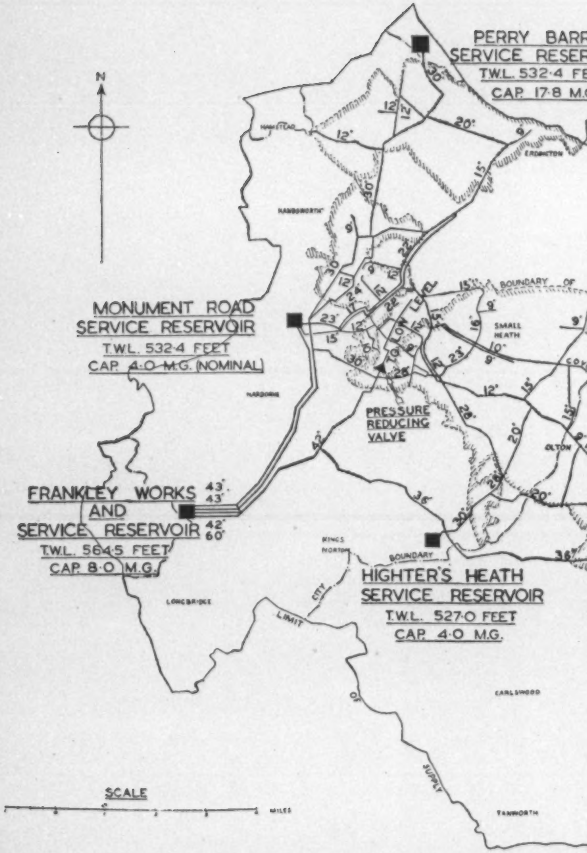
The storage reservoirs and the Frankley filtration works, which supply all five zones, are situated on high ground to the south-west of the city. The Middle Level system, of which the Perry Barr Reservoir now forms part, serves an area which extends from a belt throughout the highly-developed central area of the city to a large area adjacent to the northernmost boundary and to a very large area to the east; reaching in part to the eastern limit of supply (Plate 1) and including the highly-industrialized areas between, and adjacent to, the Coventry and Warwick Roads.

An intricate system of leading mains serves these areas, and before the completion of the Perry Barr reservoir only two service reservoirs other than that at Frankley served the zone, viz.: the Highters Heath Reservoir (T.W.L. 527 O.D.) of 4 million gallons capacity acting as a balance for the easterly portion, and the Monument Road Reservoir (T.W.L. 532.4 O.D.) of 4.15 million gallons gross capacity. The actual capacity of the latter, available for supply to the Middle Level Zone, is very much less than its gross capacity, since it is in effect a very large sump from which water is re-pumped to three higher zones and, apart from the quantity drawn off for that purpose, the water cannot be allowed to fall to low levels without adversely affecting the capacity of the pumps.

Having in mind the average daily demand of the Middle Level Zone of 20 million gallons, the available service reservoir capacity of approximately 6 million gallons (excluding Frankley Pure Water Reservoir, which serves all zones of supply), and the situation of Highters Heath and Monument Road reservoirs, it will readily be seen that not only is the supply to the large area to the north of the city greatly improved by the existence of a large service reservoir at its northern extremity but it is also of benefit to the whole zone.

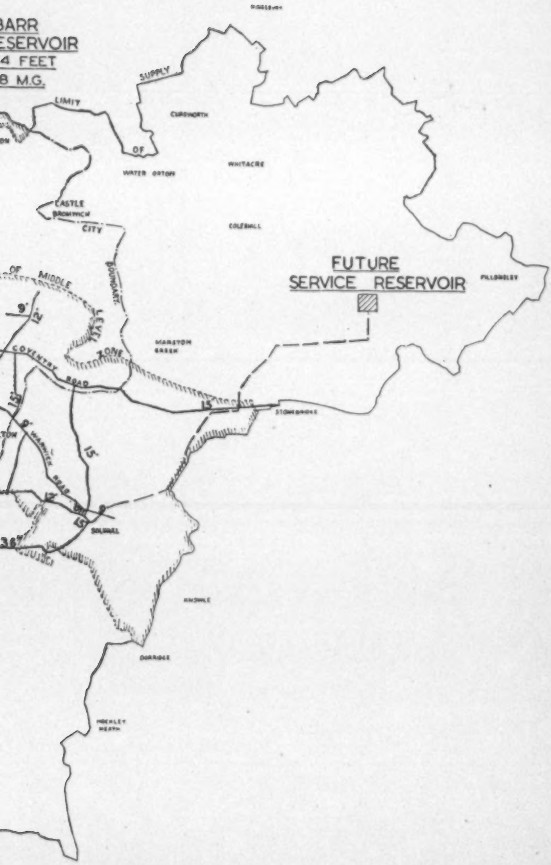
Figure 1 shows diagrammatically the effect of the reservoir on the hydraulic gradients in the mains from Frankley to the Perry Barr Area.

Pressures taken from a recording gauge situated near the end of the 30-inch supply main, before the reservoir was commenced, showed that in the day-time the hydraulic gradient produced fell below the




Plan showing system of supp

PLATE I




supply to Middle Level.

C. A. Risbridger, B.Sc., M.I.C.E.

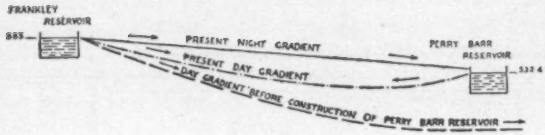



Fig. 1.

level of the bottom of the then contemplated new reservoir.

At the present time, under conditions of normal demand, the reservoir commences to fill at about 8.30 p.m. and starts to contribute to the supply at about 8 a.m., the normal day's drop in level being between 1 foot and 1 foot 6 inches, equivalent to 1.0 to 1.5 million gallons.

The gradient diagram illustrates very clearly the economic return derived from a service reservoir of this nature, for it is obvious that, with an increase in consumption, the hydraulic gradient in the mains would, in the absence of the reservoir, continue to steepen, with corresponding loss of pressure, necessitating eventually the provision of greater main capacity or the transfer of portions of the zone to the next higher.

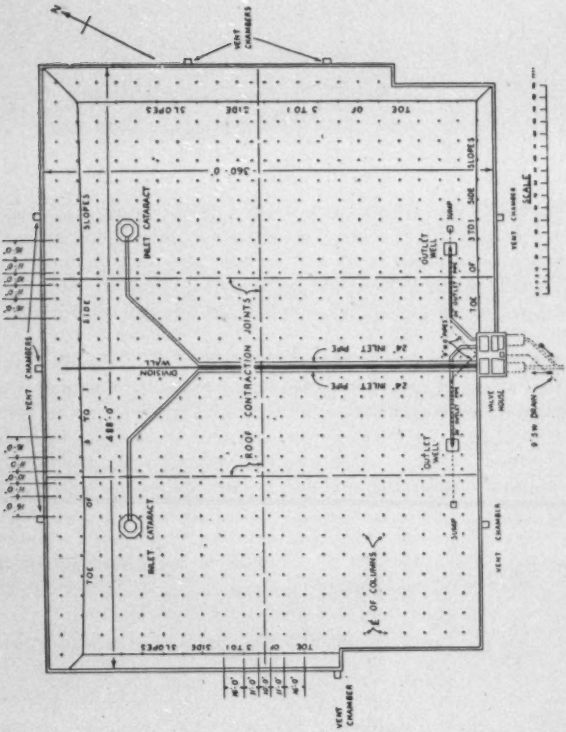
This function of service reservoirs is perhaps not quite so obvious as the fact that they constitute a guarantee of the continuity of the supply in case of main failures.

## Design

### 1. *General*

The reservoir is situated at the most northerly point of the area of supply, the eastern boundary of the enclosure coinciding with the boundary between the City of Birmingham and the Borough of Sutton Coldfield. Coal underlies the site and, in order to prevent possible future troubles from mining subsidence, the mineral rights under an area of 26 acres were purchased by the Corporation.

The reservoir at Top Water Level is 488 feet long by 344 feet wide, measured on its longest dimensions (Fig. 2), but is not truly rectangular, due to the transitions from one to another of the three




GENERAL PLAN
Fig. 2.

different sections of wall to be described later. The actual top water area is 3.86 acres, while the area covered by reservoir and embankments is 8.25 acres. The average depth of water is 18 feet and the capacity 17.92 million gallons. The foundations are in Bunter Pebble beds and trial shafts sunk before the commencement of the work disclosed sand varying in nature between a compact yellow-red deposit and very soft red sandstone. Subsequent excavation during construction

disclosed some pebbles in the lower levels. Only in one small area was it found expedient to resort to blasting. Elsewhere it was found possible to excavate by means of a tractor-drawn Le Tourneau scraper.

The reservoir is divided into two approximately equal portions by a division wall 6 feet in height, which permits of inspection of one-half while retaining 3 million gallons in the other.

### 2. *Floors*

The floor is of two courses, the lower course being 4 inches thick, of 6 to 1 unreinforced concrete laid in panels 16 feet square except in the vicinity of the roof contraction joints and adjacent to walls, where the spacing of columns changes from the normal 16 feet. Each normal panel has one column at its center and it was specified that each bay should be concreted in one operation with the column footing and screeded true to falls to a smooth finish, and that sufficient time should elapse before concreting any two adjacent bays to ensure that all initial contraction had taken place.

The upper course is 6 inches thick, of 5 to 1 concrete, reinforced at top and bottom with $\frac{5}{16}$-inch bars as shown in Figure 3. Normal bays are 32 feet long by 16 feet wide, the sides of the rectangles coinciding with column centre lines. At each edge of the slab and around each column a wedge-shaped groove 2 inches deep, ¼-inch wide at the bottom and ½-inch wide at the top, was formed for the reception of a bituminous filling. It will be seen that each panel is a separate unit laid in such manner that no interference to its movement due to initial contraction, temperature changes, etc., is offered by the columns. Futhermore, joints between upper and lower slabs are staggered the maximum amount possible.

A liberal system of underdrains was provided, the outfalls from the main drains being situated in chambers abutting on to the main walls, so that observations for possible leakage could be made periodically.

### 3. *Walls*

The walls are of gravity section, and for the sake of economy three different sections were adopted, each according to the level of the ground (Fig. 4). The maximum section is founded below the

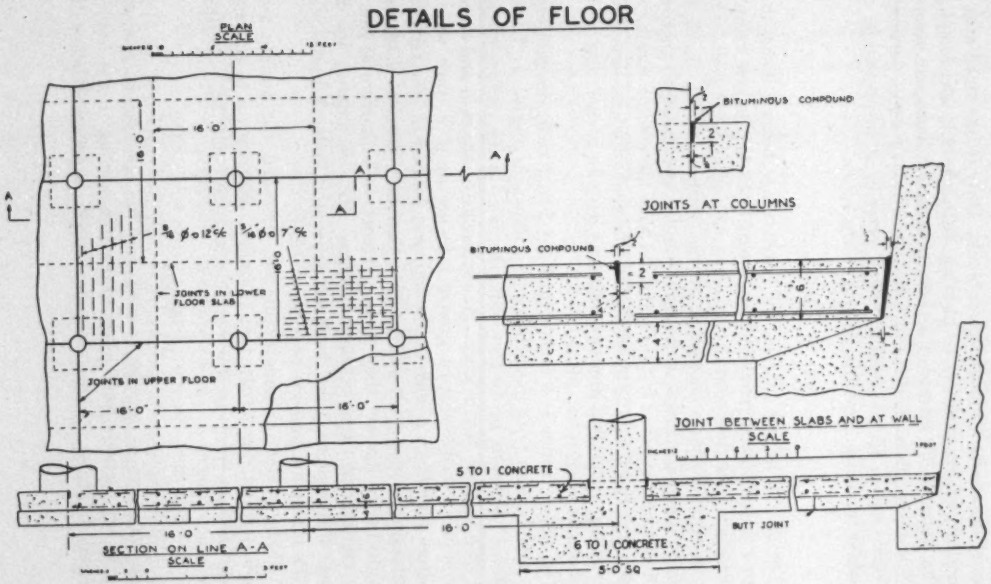

DETAILS OF FLOOR
PLAN
SCALE
16'-0"
JOINTS IN LOWER FLOOR SLAB
JOINTS IN UPPER FLOOR
BITUMINOUS COMPOUND
JOINTS AT COLUMNS
BITUMINOUS COMPOUND
JOINT BETWEEN SLABS AND AT WALL
SCALE
5 TO 1 CONCRETE
BUTT JOINT
6 TO 1 CONCRETE
5'-0" SQ
SECTION ON LINE A-A
SCALE

Fig. 3.

## DETAILS OF WALLS

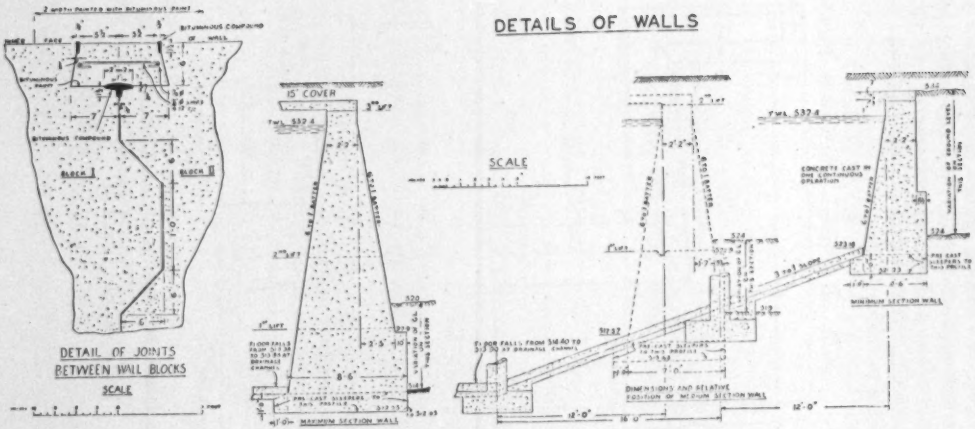



Fig. 4.

general floor level, the medium section approximately 3 feet and the minimum sections approximately 9 feet above that level, the floor being carried in a 3 to 1 slope from its general level up to the toe of the two latter walls. The method of changing from one section of wall to the other is shown in Figure 5.

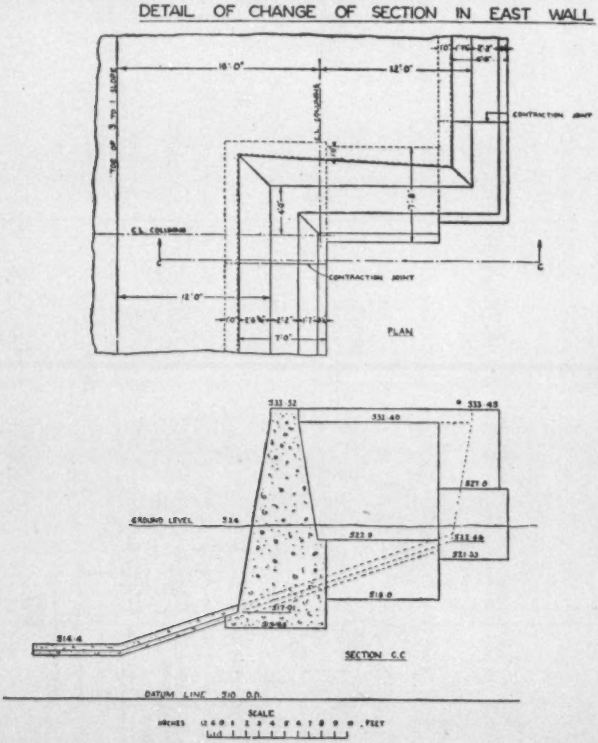



Fig. 5.

Some credit was taken in the design for the resistance moment of the earth filling. The Author is prepared to encounter some criticism on this account, but he is, nevertheless, entirely unrepentant as, having in mind the material of which the embankment is constructed, the sloping back of the wall, and the provision of a flexible joint between wall and floor, he is convinced that this was a case where practical engineering judgment properly overrules the dictates of purely theoretical considerations. In point of fact, the filling was of such a nature that, after placing in thin layers and rolling with the tractor and scraper, it was found possible to excavate a shaft 4 feet square and 3 feet 6 inches deep with vertical sides without the use of timbering. In the Author's opinion the walls undergo their severest test when the topmost layers of filling are being placed—by a tractor and scraper weighing many tons when full—before the roof is cast, and with the reservoir empty.

The theoretical maximum pressures on the foundations with reservoir full and empty were designed to be within the safe bearing capacity, which had been found by test loading to be over 3 tons per square foot without undue settlement.

The joint between wall and floor was made by forming a space between the upper 6-inch floor and the wall, $\frac{5}{8}$ inch wide at the surface of the floor and $\frac{1}{4}$ inch wide at the bottom, the space being filled with a bituminous compound after a sufficient lapse of time to ensure that all initial contraction had taken place, and after the roof over the portion being filled had been constructed.

It was specified that all walls should be constructed in sections 24 feet in length, the ends of the blocks being formed as shown in Figure 4 to receive, after an interval of at least 21 days after casting of the completing block, the inner bituminous seal and the dovetailed concrete retaining strip. The two external bituminous seals were to be placed 21 days after concreting this strip. It was further specified that the two larger section walls were to be cast in three lifts and the smallest section in two, the first horizontal joint in each case being not less than 5 feet above the foundation level. Work on each lift was to be continuous from start to finish.

### 4. *Columns*

Columns are spaced at 16 feet centres in each direction with the exception that at and adjacent to the roof contraction joints the centres are reduced to 10 feet and 11 feet respectively. The distance between end columns and the walls supporting the roof is 12 feet.

According to the D.S.I.R. Code of Practice for Reinforced Concrete, columns supporting flat slab floors should be designed to accommodate 50 per cent of the negative bending moment provided for in the column band of the roof. The necessity for this can be readily understood when the floor supported is a portion of an office or warehouse building, where heavy bending moment may be imposed on columns from "chequer board" loading of the floors, but for a reservoir roof, which has to support only a uniformly distributed dead load, with a live load at most only that imposed by an occasional light tractor and mower, no great moment can be imposed upon the columns by unequal loading of the roof bays.

Eccentric loading resulting from movement of the column heads due to expansion and contraction of the roof under the influence of temperature changes was, however, taken into account in the design.

The column bases are of 6 to 1 concrete, class 2, and the stems and truncated conical capitals of 5 to 1 concrete, class 3.

As a result of the falls of floor and roof the columns varied in height, and to provide for this the lengths of lap bars and main bars were specified to be identical for all columns, with the exception of those on the side slopes, the difference in height of the columns being compensated for by varying the overlaps.

There are in all 706 columns. In the case of the columns (as in the case of the walls), the most onerous conditions, in the Author's opinion, probably occur during construction, when fully-laden trains of jubilee skips are hauled over half-loaded bays, or when the partly-completed roof is fully loaded and subjected to the full range of temperature variation between summer and winter, with consequential expansion and contraction.

### 5. *Roof*

The roof is of the flat slab construction reinforced in two directions, 7 inches thick with dropped panels over the columns 6 feet square and 10½ inches thick, all of 6 to 1 concrete, class 2.

A continuous flat slab supported on columns is an indeterminate structure and various empirical design rules have been laid down. For Perry Barr Reservoir roof the Code of Practice of the Reinforced Concrete Structures Committee of the Department of Scientific and Industrial Research (referred to as the D.S.I.R. Code) was used. This Code requires that larger bending moments shall be provided for than are required by a typical American Code, such as the "Chicago Ruling," which was used as the basis of a design for the roof of another reservoir before the publication of the D.S.I.R. Code. In the use of this latter Code the only point on which doubt was felt was the arrangement of the steel. In applying the Chicago rule, double-cranked bars with hooked end had been found to give a very rigid network of bars not easily displaced during the placing of concrete. The D.S.I.R. Code specifies single-cranked bars, which it was felt might lead to some difficulties in fixing which would lead to displacement during concreting.

In order to determine which arrangement of reinforcement with sensibly equal quantities of steel gives the stronger structure, two models were constructed to a horizontal scale of one-quarter. The thickness of the slabs and the reinforcement were so designed that the loading per square foot to be imposed on the model would produce the same steel stresses as an equivalent load would produce on the full scale, and further by allowing a low design stress for the concrete it was arranged that, if tested to destruction, the model would fail by overstressing the steel rather than the concrete. The span of the model slabs was 4 feet and the total thickness 1½ inches.

Load-deflection figures were taken for both models up to 50 per cent over designed load and then loading was continued to 2¼ times the designed load. This loading, applied in the form of lead pigs and blue bricks, was limited by the stock available and so neither slab actually failed, but examination after removal of the load showed considerable cracking in the tension surfaces, indicating an overstressing of the steel. This cracking was very extensive in the model reinforced with double-cranked bars, and cracks opened up to 15 thousandths of an inch. In the model reinforced with single-cranked bars, strictly in accordance with the D.S.I.R. Code, only minor cracking occurred, up to a maximum opening of 6 thousandths of an inch. The

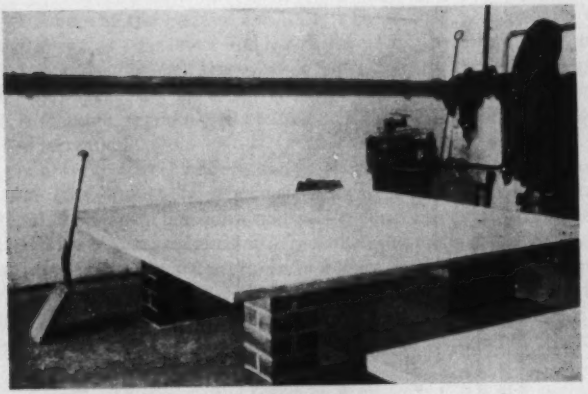
position of the cracks in this model also indicated a much better distribution of steel in relation to bending moments. This arrangement of steel was, therefore, adopted for the Perry Barr roof and, by the provision of some additional bars, whose sole function was to induce rigidity in the network during concreting, no constructional difficulties were experienced.

Two photographs herewith show the models before and during test.

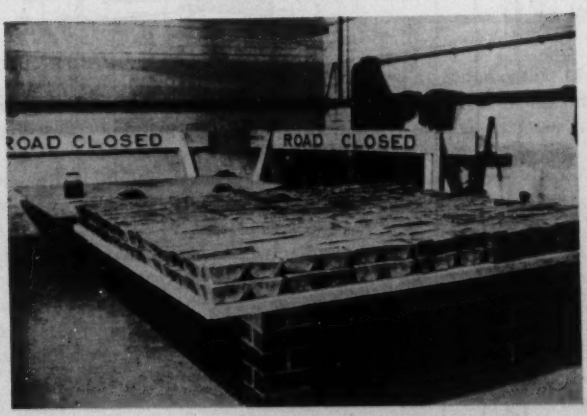
In order to avoid excessive expansion and contraction the whole roof was divided into six approximately equal areas by the provision of contraction joints, which were formed as shown in Figure 6 by the provision of cantilever bays 5 feet long, the end face of the roof slab being shaped to accommodate a copper strip and a bituminous filling as shown.

It was specified that, in order to provide a sliding surface for the roof, the tops of walls should be finished to a smooth surface. Shortly after the completion of the first portion of the roof, extending right across the short length of the reservoir, and before the placing of the soil covering, an exceedingly hot summer day occurred and a crack appeared on the inner face of one wall block about 2 feet below the roof level, indicating that the roof was not sliding but was trying to push the wall over. Thereafter a strip of rubberoid felt the width of the wall top was laid on the wall before placing the roof concrete. This bonding of the roof to the wall top is probably typical of many cases where a result, usually impossible of achievement without special measures, was achieved in spite of measures designed to prevent it. The portion of the wall affected was, of course, cut out and recast. It may be thought that this *contretemps* was caused by faulty setting of the roof shuttering or by its settlement during concreting, leaving the soffit of the roof below the top of the wall and thus forming a rebate which would allow the roof to exert a direct pressure against the wall. Such a contingency had, however, been foreseen and provided for by specifying that the walls were to be finished 1 inch below roof level, the additional inch thickness being cast with the roof, making the latter in effect 8 inches thick over the walls.

The roof has a covering of sand and soil to a depth of 15 inches drained by 2-inch and 3-inch agricultural tile drains, falling to drain-



MODEL BEFORE TEST




MODEL DURING TEST

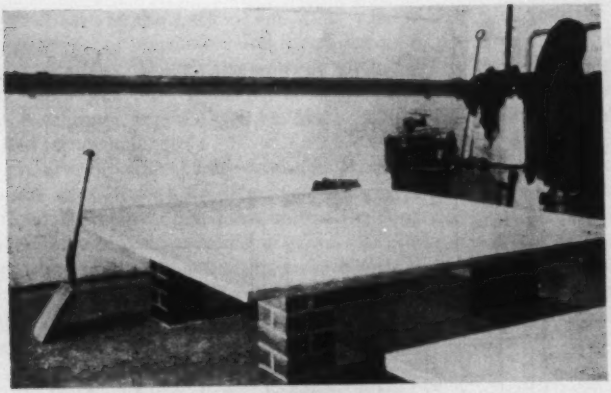
position of the cracks in this model also indicated a much better distribution of steel in relation to bending moments. This arrangement of steel was, therefore, adopted for the Perry Barr roof and, by the provision of some additional bars, whose sole function was to induce rigidity in the network during concreting, no constructional difficulties were experienced.

Two photographs herewith show the models before and during test.

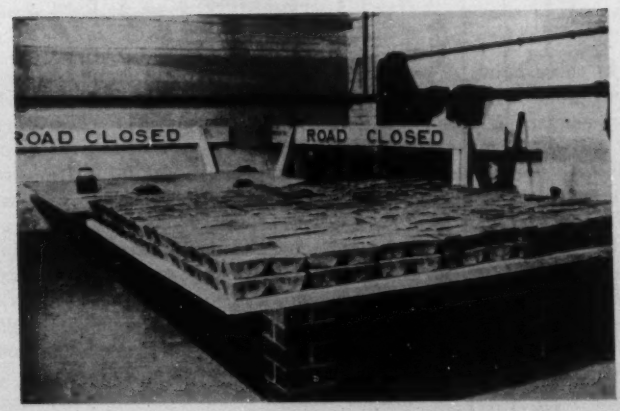
In order to avoid excessive expansion and contraction the whole roof was divided into six approximately equal areas by the provision of contraction joints, which were formed as shown in Figure 6 by the provision of cantilever bays 5 feet long, the end face of the roof slab being shaped to accommodate a copper strip and a bituminous filling as shown.

It was specified that, in order to provide a sliding surface for the roof, the tops of walls should be finished to a smooth surface. Shortly after the completion of the first portion of the roof, extending right across the short length of the reservoir, and before the placing of the soil covering, an exceedingly hot summer day occurred and a crack appeared on the inner face of one wall block about 2 feet below the roof level, indicating that the roof was not sliding but was trying to push the wall over. Thereafter a strip of rubberoid felt the width of the wall top was laid on the wall before placing the roof concrete. This bonding of the roof to the wall top is probably typical of many cases where a result, usually impossible of achievement without special measures, was achieved in spite of measures designed to prevent it. The portion of the wall affected was, of course, cut out and recast. It may be thought that this *contretemps* was caused by faulty setting of the roof shuttering or by its settlement during concreting, leaving the soffit of the roof below the top of the wall and thus forming a rebate which would allow the roof to exert a direct pressure against the wall. Such a contingency had, however, been foreseen and provided for by specifying that the walls were to be finished 1 inch below roof level, the additional inch thickness being cast with the roof, making the latter in effect 8 inches thick over the walls.

The roof has a covering of sand and soil to a depth of 15 inches drained by 2-inch and 3-inch agricultural tile drains, falling to drain-



MODEL BEFORE TEST




MODEL DURING TEST

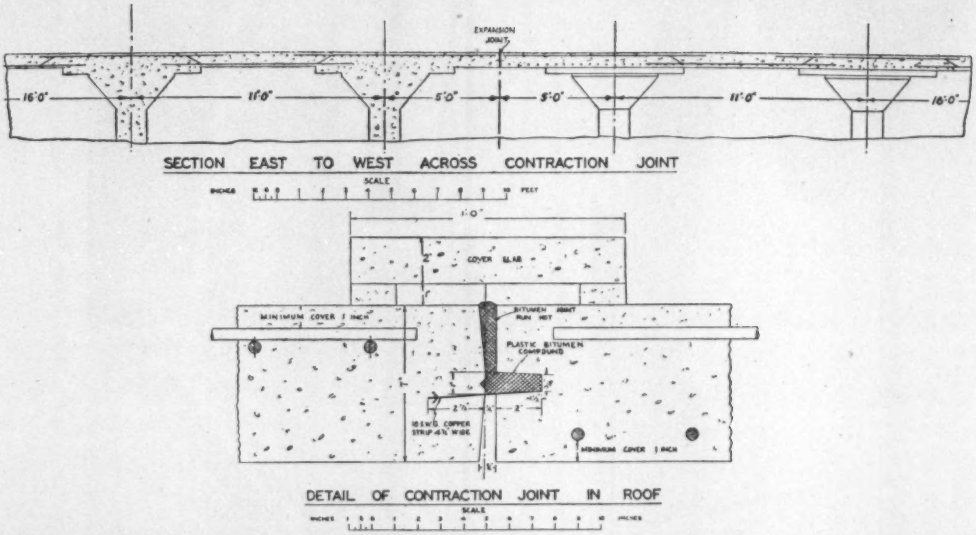

EXPANSION JOINT
16'0"
11'0"
5'0"
5'0"
11'0"
16'0"
SECTION EAST TO WEST ACROSS CONTRACTION JOINT
SCALE
INCHES
FEET
1'0"
2" COVER SLAB
MINIMUM COVER 1 INCH
BITUMEN JOINT RUN HOT
PLASTIC BITUMEN COMPOUND
16 S.W.G. COPPER STRIP 6" WIDE
MINIMUM COVER 1 INCH
DETAIL OF CONTRACTION JOINT IN ROOF
SCALE
INCHES

Fig. 6.

age chambers at the back of the walls. These chambers are also designed to act as ventilators for the reservoir by the provision of rectangular orifices through the walls of the latter. By this means a perfectly unbroken level grass surface is provided over the reservoir so that, if required, it could well be used as a football ground or for some similar recreation.

In order to collect information on the movement of reservoir roofs of large area, three sets of gauge points were embedded in the concrete, at the contraction joint and at the junctions between roof and walls, all set in one straight line across the minor axis of the reservoir. The gauge points are set as shown in Figure 7, so that their distances apart may be measured by a caliper gauge or micrometer. Unfortunately the war intervened and up to the present, owing to shortage of staff, it has not been possible to obtain a continuous set of readings.

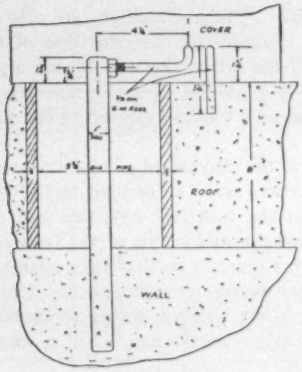
### 6. *Division Wall*

The division wall is designed as a cantilever, as shown in Figure 8, and constructed in individual lengths of 50 feet, a copper strip and bituminous contraction joint being provided between each length.

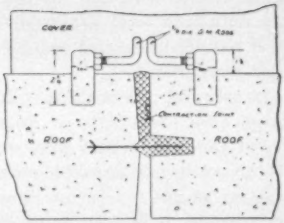
### 7. *Valve Chamber, Valve House, Pipe Arrangements*

The pipework was so designed as to allow accommodation of all valves in one chamber and operation from one house. A single main acts as inlet and outlet main, bifurcating near the valve chamber from one of 30 inches diameter into two 24-inch branches (see Fig. 9). The western branch includes a reflux valve which operates to allow flow into the equilibrium valve chamber, but prevents flow out, and has a manually-operated guard valve on its upstream side. The equilibrium valve, which is not designed to be drop-tight, is set to close an inch or two below T.W.L. to provide sufficient freeboard between that level and overflow level to accommodate the slight leakage through the valve during week-ends and holidays when the reservoir stands full for long periods.

From the equilibrium valve chamber two 24-inch inlet pipes lead through a chamber housing manual control valves and pass thence through the reservoir walls emerging one on each side of the division




CONTRACTION GAUGE TYPE 1
AT WALL

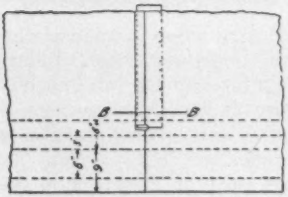



CONTRACTION GAUGE TYPE 2
AT CONTRACTION JOINT

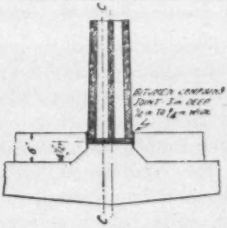
Fig. 7.

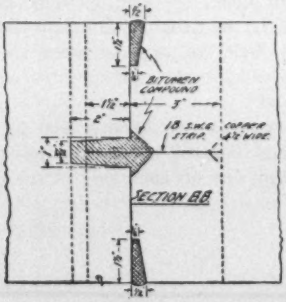
DIVISION WALL
DETAILS OF CONTRACTION JOINTS

LONGITUDINAL SECTION ON LINE C.C.




CROSS SECTION OF WALL AT JOINT



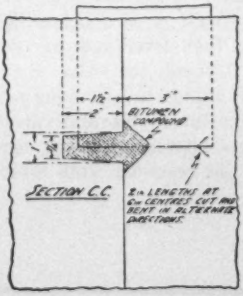




Fig. 8.

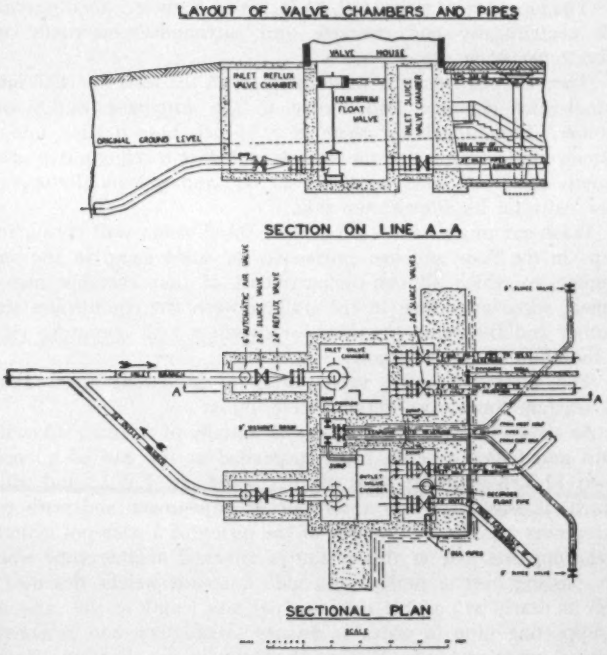



Fig. 9.

wall, and terminating at a point remote from the valve chamber, in octagonal brickwork enclosures from which the water cataracts to the floor through stilling pools. Inside the reservoir the inlet pipes are of spun concrete.

The discharge pipes commence from each side of the division wall near the valve chamber from horizontal bell-mouths arranged with their lips approximately 4½ inches above the general floor level, in order to exclude silt which may collect on the floor.

The pipes are of mild steel, 24 inches in diameter, lined internally with centrifugally-spun concrete and surrounded externally with concrete placed *in situ*.

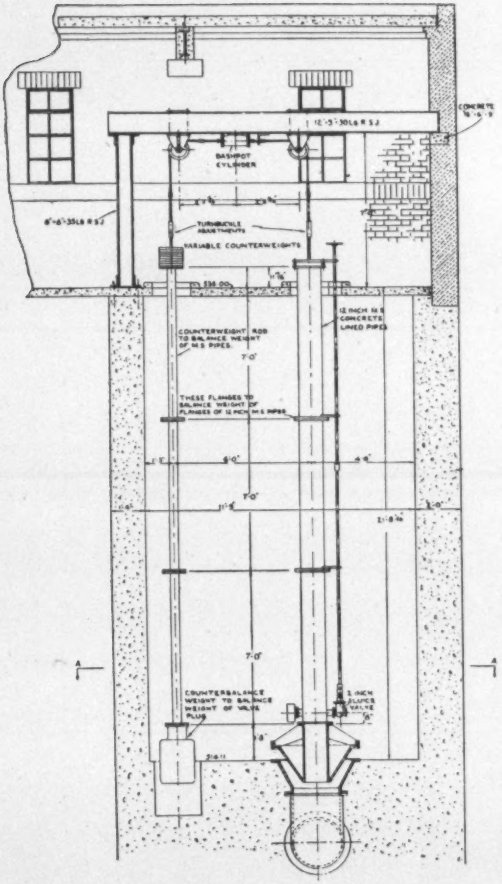
They emerge from the reservoir through the reservoir wall into a manual-valve chamber and thence to the automatic outlet valve chamber. From the latter there is a 24-inch branch back into the common inlet-outlet main, the branch including a reflux valve, which prevents entry of water to the reservoir, and a manually-operated sluice valve on its downstream side.

Wash-out pipes from each side of the division wall spring from sumps in the floor and are carried to the main sump in the valve chamber, to which all sub-compartments of that chamber may be drained, while an orifice in the wall between the equilibrium valve chamber and the sump provides for overflow. All operating valves are therefore under one roof.

The automatic outlet valve, being of somewhat novel design, may warrant some more detailed description.

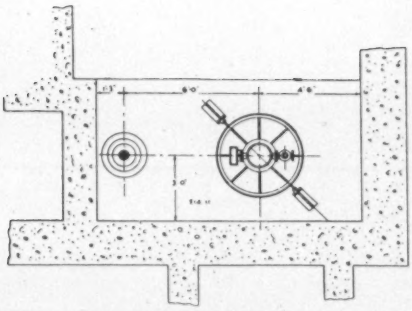
As shown in Plate 2, it consists essentially of a truncated conical mouth and hollow-tapered plug, suspended at the end of an open-topped 12-inch diameter pipe which rises above T.W.L. and which, in turn, is suspended by a turnbuckle adjustment and wire rope passing over a pulley to one side of the piston of a dash-pot cylinder. To the opposite side of this piston is attached another rope which, after passing over a pulley, suspends a counterweight designed to weigh as nearly as possible the same per unit length as the valve and its supporting pipe in order to ensure satisfactory and reasonably sensitive operation at any level of the water in the chamber. Having in mind the fact that the weight of a body in air is greater than its apparent weight in water, it is obvious that, if the balancing had been attempted by suspending a concentrated weight at the end of a rope, a state of unbalance tending to close the valve would have resulted from a fall in water level. Additional weights may be placed as required on the counterweight side to provide for operation at varying rates of outflow.

The valve operates to close in case of a burst main when the velocity through the annulus between the plug and pipe increases beyond a critical point, so reducing the pressure under the plug that the



CONCRETE
12'-3"-30LB R.S.J.
BASHPOT CYLINDER
TURNBUCKLE ABUTMENTS
VARIABLE COUNTERWEIGHTS
12 INCH M.S. CONCRETE LINED PIPES
COUNTERWEIGHT ROD TO BALANCE WEIGHT OF M.S. PIPES
7'-0"
THESE FLANGES TO BALANCE WEIGHT OF FLANGES OF 12 INCH M.S. PIPES
6'-0"
4'-0"
7'-0"
7'-0"
COUNTERBALANCE WEIGHT TO BALANCE WEIGHT OF VALVE PLUG
2 INCH SLUICE VALVE
A
A

PLATE 2



SECTION ON A - A

SCALE

GENERAL ARRANGEMENT OF AUTOMATIC OUTLET VALVE

C. A. Risbridger, B.Sc., M.I.C.E.

static pressure on its upper side overcomes the balance weights. Closing takes place very gently through the influence of the dash-pot, and the formation of a vacuum beneath the plug is prevented by the provision of direct communication with the atmosphere through the hollow plug and pipe. The valve seats on a gutta-percha ring pinched in the flange of the taper pipe. To reset the valve after closure, the manual valve on the outlet branch is closed, the 2-inch valve on the short branch at the bottom end of the pipe supporting the plug is opened, and water from the chamber is allowed to fill the main down to the closed manual valve, when the automatic valve is easily reset by the addition of more balance weights, or by a man standing on the counterweight side. Alternatively, when the main is repaired and recharged throughout, the valve will reset itself. Up to the present time no failure on the system of mains has occurred to test this valve in the actual circumstances which it was designed to meet, although on one occasion when, in order to assist a lower level system, a 10-inch interconnection was opened, the resulting flow from the Middle Level system was sufficient to operate the valve. In addition, it has been tested upon occasions by inducing an abnormal outflow by opening wash-out valves, and on each occasion it operated smoothly and effectively. It may, therefore, be confidently anticipated that it will operate when the much greater flow which results from a main failure takes place.

## Constructional Details

### 1. *Concrete and Concreting*

*(a) Aggregates.*

Stone for concreting consisted of washed crushed pebbles of three grades:—

(1) All to pass in every dimension a screen having 1¼ inch square meshes, and all to be retained on a screen having ¾ inch square meshes.

(2) All to pass in every dimension a screen having ¾ inch square meshes, and all to be retained on a screen having ⅜ inch square meshes.

(3) All to pass in every dimension a screen having ⅜ inch square meshes, and all to be retained on a screen having 3/16th-inch square meshes.

Each grade of stone and the sand were stored in separate hopper-bottomed bins, all arranged in line with the hopper and the tremie from the cement shed.

*(b) Mixes.*

The concrete was specified to be of three classes, viz:—

6 to 1 .. Class 1.
6 to 1 .. Class 2.
5 to 1 .. Class 3.

6 to 1, class 1, concrete was specified to consist of aggregates of Grades 1, 2 and 3, sand and cement, the proportion of the aggregate to be determined by tests to give the densest mixture. The proportion of sand required was then determined by the measurement of voids.

Since drawing up the specification on the lines indicated above, the Author has been converted to the Fineness Modulus method of designing concrete mixes and, as a matter of interest, compared the proportions of the classes of concrete used on the Perry Barr work as obtained by the method described above and designed by the Modulus method, and found them to be in very close agreement; but whether the same agreement would result with every type of aggregate and all mixes he is not prepared to say. There is, however, no question that careful experimenting with available aggregates must produce the best concrete, albeit the process may take considerably more time than the Modulus method, since the latter involves working to limiting curves published by authorities who must obviously have carried out a large number of tests to establish those curves.

The Author considers that, in order to produce consistently good concrete, it is essential not only so to specify that the actual proportions of the large and fine aggregates shall be determined by tests on those aggregates as actually delivered, but also to provide for periodic retesting to cope with the changing fineness modulus which results, as the work proceeds, from wear of the quarry screens and other causes.

6 to 1 concrete, class 2, and 5 to 1 concrete, class 3, consisted of aggregates of Grades 2 and 3, sand and cement in proportions determined by similar methods, and were used in thin sections and in reinforced work.

*(c) Water.*

The amount of water was again determined by tests with each class of concrete before specifying the "slump" allowable since, here again, the Author attaches little value to a slump figure specified before tests are carried out on the actual mixes used.

*(d) Bulking of Sand.*

Frequent tests were carried out to determine the moisture content of the sand, and appropriate allowance made in the sand content for "bulking" and in the water content.

*(e) Gauging.*

The specification called for gauging of aggregate by an approved method of automatic weighing, the plant used consisting, in brief, of a travelling hopper running beneath all the bins and the cement shed. The hopper embodied a weighing machine with recorder arms upon which the prescribed weights of each separate constituent could be set so that the operator had only to watch his gauge while filling, and shut the bin at the appropriate moment shown by an indicator. The concreting inspector set the indicator arms to give the appropriate mix and retained the key to the enclosing box. One inspector was in constant attendance at the mixing plant.

It was further specified that the basis af all mixes was to be one bag of cement or a whole-number multiple of a bag, which was not weighed at the mixing plant. It was subsequently found, however, that the economical mix for the plant would result from a cement content of 1½ bags. To ensure that an accurate measure of 1½ bags per mix would be maintained without weighing, a box hopper was constructed in the shape of a frustum of an inverted square pyramid and of a capacity exactly equal to one bag. It was divided into two exactly equal parts by a metal partition the top of which finished about 1 inch below the level top of the hopper, thus allowing the heap which resulted from tipping the cement to be screeded level.

For each mixing, one whole bag and the contents of one compartment were used.

### 2. *Programme of Construction*

The general scheme of construction provided for commencement of the excavation at the east end of the works followed by the concreting of walls, lower floor with column bases, column stumps, columns, roof and, finally, the upper floor, proceeding westward in that sequence to complete at the west end, with the exception that one bay in the southern wall by the mixing plant was omitted for the purpose of the final withdrawal of plant.

### 3. *Excavation*

Except for one very local area upon which explosives were used, all excavation was carried out by one 8-cubic yard Le Tourneau scraper which not only proved a most efficient excavator, but also an excellent roller for the embankments, since, in addition to its very heavy weight, it could only deposit its load in thin layers.

In order to ensure satisfactory foundations it was specified that bulk methods of excavation should be used to a level not lower than the upper surface of the lower floor slabs, the remaining excavation to the underside of those slabs being taken out immediately before depositing the concrete. A similar clause provided that no excavation for any work should be carried lower than 4 inches above formation level, until immediately before placing concrete.

Two separate items for excavation were therefore included in the bill of quantities, one for bulk excavation and one for the final 4 inches.

By the insertion of such clauses and by insisting upon their observance, not only does a good formation result, but the contractor is saved the expense of having to carry foundations below their designed level without extra payment; for a keen contractor's agent is usually optimistic enough to believe that there will be no heavy rain between the finishing of his bulk excavation and the placing of the concrete and, if he has been given the opportunity to enter a separate price for the hand excavation, the temptation to "take a chance" is diminished if not altogether removed.

### 4. *Floors*

The concreting of the lower floor panels was carried out in a pattern such that no bay was cast in contact with another until the lapse of at least seven days after the casting of the adjacent bay.

Since the slab was cast in one operation continuous with the column footing, which to the level of the top of the lower floor was 1 foot 5 inches deep, while the floor was only 4 inches thick, it might be expected that contraction cracks would develop at the change of section, particularly as the lower floor slabs were of unreinforced concrete; in practice, however, in no case did this occur. As soon as possible after casting, the edge shutters were removed and the edges picked over and, during the casting of adjacent bays, a ½-inch thickness of 2 to 1 cement mortar was applied, not in the hope that any permanent adherence would result over such a large floor area, but to avoid honeycombing at the joints.

Immediately after concreting any floor slab, prefabricated cloth and timber covers were placed over it and kept damp for periods varying between 7 and 21 days, dependent upon weather conditions.

In order to minimise temperature range, to provide concreting room on wet days, and to protect the concrete from drying winds and direct sun, it was specified that no upper floor bay should be concreted until the roof over that bay and adjacent bays had been constructed.

The tapered grooves at the edges of every bay and around columns were formed by inserting appropriately shaped steel strips immediately upon completion of the concreting, thus enabling proper ramming and spading against the shutters to be performed without interference from or with the groove forms. After a sufficient interval to ensure that all initial contraction had taken place, the grooves were thoroughly cleaned and dried, primed with bitumastic paint and filled with a hot-run bituminous compound.

Placing the concrete on the 3 to 1 side slopes required considerable care and a nice adjustment of the water content in order to prevent slumping down the slope during the screeding operations. In fact, it had to be placed in a somewhat drier condition than the Author at first considered consistent with the production of water-

tight work. In order to put the matter to the test, however, metal moulds—2 inches deep by 5 inches internal diameter—were placed in the concrete as it was being cast, and were subjected, with that concrete, to the normal screeding and ramming processes, no special attention being given to their vicinity. They were subsequently removed and the test cylinders subjected to water penetration tests.

Water under a head of 49 feet was applied to one face of the block when the latter was eight days old. Any water which completely penetrated the block was caught and weighed at intervals with the results shown in the following table:—

| Duration of Test (Days) | Water Collected per 24 hours (m.l.) |
|---|---|
| 1 | — |
| 2 | 3.1 |
| 3 | 5.0 |
| 4 | 1.9 |
| 5 | 0.4 |
| 6 | 0.2 |
| 7 | Nil |
| 8 | Nil |

When the block was broken open the concrete revealed was of close texture with few visible voids.

In view of the fact that the test was carried out at about 2½ times the maximum head to which the floor would be subjected, and that the block was only 2 inches thick, while the actual floor is 6 inches thick, no misgiving remained on the question of water-tightness.

It will be noted that the percolation shown in the table rose to a maximum during the third day and then fell to nil by the end of the sixth day, demonstrating the self-staunching properties of well-graded concrete. Nevertheless, the Author considers that a somewhat flatter slope would be more economical, in view of the difficulties encountered with the 3 to 1 slope.

That the floor is liberally provided with underdrains, and the reservoir has been in service for nearly five years without any trace of leakage, is, however, reasonable proof that concrete on such a slope can, with care, be made water-tight.

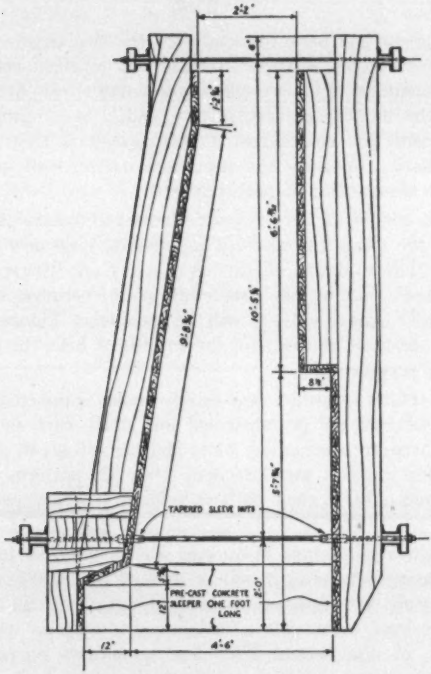
### 5. *Walls*

Although it had been specified that the two larger section walls were to be concreted in three lifts and the smallest section in two lifts, the intention was to reduce the number of lifts, and consequently the number of construction joints, to a minimum. After discussion with the contractors it was agreed to cast the medium section walls in two lifts, and the small section wall in one operation, to the satisfaction of both parties.

To the contractor, every joint eliminated meant the saving of the cost of the treatment specified for making good new work to old, and enabled him to design his lifts so that any one lift represented the continous operation of his concreting plant between starting and "knocking-off" times, and—as will be seen from Figure 4—enabled him to use the same shutters for the top lift of both the greatest and the medium section walls.

These shutters were of very heavy timber supported and braced with M.S. sections and prefabricated into units, each unit being the full length between contraction joints and the full depth of the appropriate lift for which it was intended. Only six patterns were necessary, and one only of each pattern sufficed to carry out the whole work.

Although very heavy, they were easily handled by the crane used for placing concrete. It will be noticed that the first lift of the two larger walls was finished about 4 inches above the level of the offset at the back to provide a convenient footing on which to land the shutter of the second lift. For a similar purpose, precast "sleepers," 1 foot in length, measured along the face of the wall, and of a section conforming with the wall footings up to the inner angle between toe and face (Fig. 10), were accurately laid at about 7 feet centers to align and level the bottom shutters. The latter were then braced together against these sleepers and against struts placed above concrete level by M.S. bolts the nuts of which were machined, conical-shaped sleeves, protruding into the concrete section approximately 3 inches, and screwed on to the bolts, the ends of which finished about 2 inches from the face of the wall, so that when the nuts were removed they left conical voids which were subsequent-




SHUTTERING FOR MINIMUM SECTION OF WALL

Fig. 10.

ly filled with cement mortar. The bolts remained embedded in the concrete but with ample cover to prevent corrosion (Fig. 10).

It was found possible to strip the shutters from within 24 hours after placing the concrete, but covers were draped over the new concrete and kept damp for some days according to the weather prevailing.

The method specified for making good new concrete to old involved wire-brushing the surface of the newly-placed concrete as soon as it had sufficiently hardened to allow the exposed mortar to be brushed away, leaving the aggregate protruding about ¼-inch. Before placing new concrete on that surface the latter was thoroughly hosed, all surplus water brushed off and 2 to 1 cement mortar spread over to a depth of ½ inch, the necessary amount being accurately gauged by calculating the volume required. It was one of the duties of the inspector on the mixing plant to ensure that no concrete was turned out until the requisite quantity of mortar had been made.

Before specifying this method of bonding new work to old, the Author carried out tests by making 6-inch cubical blocks in pairs bonded together as described and embodying, at each end of the resulting 6-inch × 6-inch × 12-inch long blocks, an iron hook bolt. A direct pull was exerted through these bolts to pull the joint apart. The results were very satisfactory and in one case the block actually broke at a section which was weakened by the presence of the bolt head rather than at the joint itself.

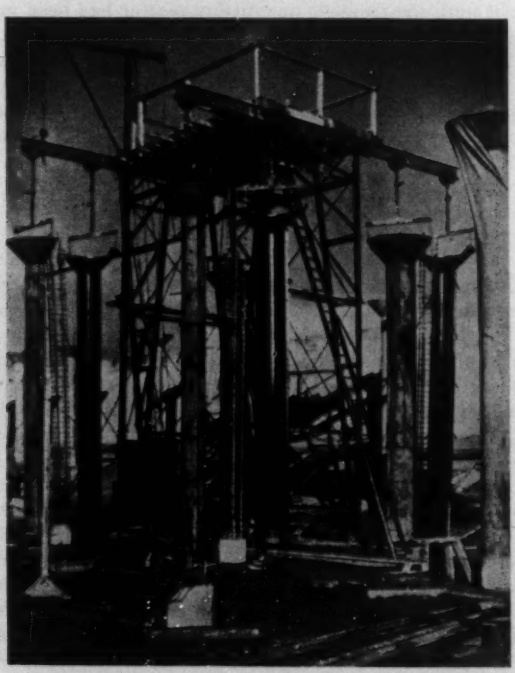
### 6. *Columns*

It has already been mentioned that the column footings were concreted in one operation with the lower floor bays, and short column starting bars were left protruding above the floor a sufficient distance to allow a short length of column ("the stump") to be concreted above that level to act as a support for the main column forms. These footings were designed to be 17 inches thick but it had been observed when concreting the walls that the sandy formation tended to absorb moisture from, and mix with, the bottom inch of concrete. It was therefore decided to increase the thickness of the column footings by 1 inch to ensure that the steel would have 2 inches cover of high-quality concrete, the actual cover being thus 3 inches.

The column forms were made of steel plate in two semicircular sections, stiffened longitudinally with angles which also served to bolt the two halves together. Each form was the full height of the column from a few inches below the top of the stump to the top of the conical capital. Only four forms were used for the whole work—with the exception of one special form for the short columns on the side

slopes—and were suspended in eight halves, each from a roller running on R.S.J.'s which formed part of a concreting platform erected on tubular scaffolding. This erection, known as "Jumbo," was on wheels, could be moved as required, and was designed to allow the concreting of four columns at one setting (see photograph).

Concrete was lifted to the platform in special skips by a Neal's crane with jib extension. Concreting of each column was carried out continuously from start to finish, external pneumatically-operated vibrators being used for consolidation.



"JUMBO"

The method produced very satisfactory concrete, but great care had to be taken to ensure a water-tight joint between the shutter halves and between shutter and stump, to avoid local surface defects in the vicinity of those joints due to the run of water expressed from the concrete by the vibrators. In order to maintain the steelwork in its proper position, a small section of concrete 1 inch thick, shaped to the correct radius and with a hole cast in it, was threaded over each main bar during assembly and wired in position.

The underside of each block sloped upwards to prevent air or water lock under them during casting of the columns. When the forms were erected they served as accurate distance pieces and so well did they bond to the vibrated concrete that after concreting they could only be found by a very minute search.

The total number of columns was 706, including the 49 short columns on the 3 to 1 side slopes.

### 7. *Roof*

The roof shuttering was constructed in panels of T .& G. timbers. Each main shutter was somewhat in excess of the 16-foot length of one bay and of width just short of the distance between the faces of two adjacent roof drops, i.e. a little under 10 feet. Each was mounted on its own tubular scaffolding carriage, which was moved forward as the work progressed. Separate panels were made to fill in the gaps between adjacent main shutters, and were supported from the carriages of the latter. The forms for the roof drops were of steel, made in two halves, and were clamped around the short vertical top of the column capital provided for that purpose and supported on bearers suspended between the main shutters. Enough shutters were made to concrete one complete bay across the minor axis of the reservoir.

The carriages were moved forward from bay to bay on rollers, jacked up into the approximately correct position, the rollers removed and timber packings substituted; then the final adjustment to correct level was made by driving folding wedges under the carriage foot packings. Since the construction joints were made at the centres of panels this method of shuttering made it impossible to support the leading edge of the concrete, when stripping took place, until the main

shutters had been moved forward to their next setting. Some apprehension was therefore felt that in the process the leading half-bay might suffer damage, since it would be acting as a cantilever 8 feet long if reckoned from the column centre lines, or 5 feet long reckoned from the line of the near edges of the roof drops. Since, in the flat slab design, there was no effective top steel, either in the column bands or the mid-bands, protruding much beyond the latter line, to leave those bays unsupported for any length of time, however short, appeared somewhat risky. However, no ill results ensued, and of course only one bay was stripped at a time and struts placed under the leading edge of the column band of the finished roof as soon as each shutter finished its travel to the next position.

Such a method of shuttering is possible only with a flat slab design, and is one of the advantages of the latter over a beam and slab construction.

The roof contraction joints were made as shown in Figure 6 and some difficulty was experienced in obtaining a completely water-tight job until the work shown above the actual roof level was added. The spans adjacent to these joints were made 10 feet long, giving cantilever spans of 5 feet. The next spans were made 11 feet to fit in with the general arrangement, since the three spans at and on either side of the joint total 32 feet, i.e. twice the normal span. End spans adjacent to walls were made 12 feet long to provide for the greater moments which occur in end spans of a series of continuous beams.

The specification provided that tests upon the completed roof were to be carried out if required. One panel of the normal 16 feet span was therefore chosen at random and loaded to twice the working load, the deflection at the centre of the span being determined by a micrometer dial gauge. Commencing with the roof entirely unloaded, earth was deposited as uniformly as possible on the test panel and surrounding panels covering a total area of 80 feet square.

Readings of the deflection were taken after every 3-inch layer was deposited up to the normal total depth of 15 inches. The load at this stage amounted to approximately 230 lbs. per square foot, including the weight of the concrete slab itself. The corresponding central deflection was 0.029 inch, equivalent to 0.00015 of the span.

Additional earth was then deposited in 3-inch layers over the test panel and over the immediately adjoining panels up to their centre

lines. Deflection readings were taken after the placing of each layer up to the full test load of 30 inches of earth, or 370 lbs. per square foot. The maximum deflection at full load was 0.055 inch equivalent to 0.00029 of the span.

After an interval of 24 hours, during which time the deflection remained constant, the earth fill was completely removed in successive 6-inch layers, deflection readings being taken at each stage. No permanent deflection remained. The results of the test are given in the following table.

RESULTS OF ROOF DEFLECTION TEST

| Time Interval (days) | Depth of Earth (inches) | Earth Load (lbs./sq.ft.) | Total* Load (lbs./sq.ft.) | Dial Reading (inches $\times 10^{-3}$) | Deflection of Roof Slab (inches $\times 10^{-3}$) | Remarks |
|---|---|---|---|---|---|---|
| | 0 | 0 | 90 | 61 | 0 | |
| 2 | | | | | | |
| | 3 | 28 | 118 | 65 | 4 | |
| 3 | | | | | | |
| | 6 | 56 | 146 | 70 | 9 | |
| 8† | | | | | | |
| | 9 | 84 | 174 | 79.5 | 18.5 | |
| 2 | | | | | | |
| | 12 | 112 | 202 | 82 | 21 | |
| 18† | | | | | | |
| | 15 | 140 | 230 | 90 | 29 | Loading |
| 2 | | | | | | |
| | 18 | 168 | 258 | 97 | 36 | |
| 2 | | | | | | |
| | 21 | 196 | 286 | 103.5 | 42.5 | |
| 0 | | | | | | |
| | 24 | 224 | 314 | 107 | 46 | |
| 3 | | | | | | |
| | 27 | 252 | 342 | 112 | 51 | |
| 1 | | | | | | |
| | 30 | 280 | 370 | 116 | 55 | |
| 1 | | | | | | |
| | 30 | 280 | 370 | 116 | 55 | |
| 3 | | | | | | |
| | 24 | 224 | 314 | 110.5 | 49.5 | |
| 6 | | | | | | |
| | 18 | 168 | 258 | 101.5 | 40.5 | |
| 24‡ | | | | | | Unloading |
| | 12 | 112 | 202 | 75 | 14 | |
| 14‡ | | | | | | |
| | 6 | 56 | 146 | 64 | 3 | |
| 5 | | | | | | |
| | 0 | 0 | 90 | 61 | 0 | |

* Figures for total load include 90 lbs./sq.ft. for average weight of roof slab.
† Delays due to snow.
‡ Delays due to labour shortage.

In connection with the figures given in the table it should be noted:

(1) No allowance has been made for compression of the columns under load. Since, however, the strain is directly proportional to the applied load, and as the induced stresses were within the elastic limit of the concrete, it can be safely assumed that the columns would return to their original length when unloaded.

(2) The apparatus would record any settlement of the column foundations, but since there was no residual deflection of the roof, there could have been no measurable settlement of the columns.

(3) No allowance was made for the considerable variations of temperature which occurred during the testing period, it being assumed that any downward movement of the plumb-bob would be substantially equivalent to the upward movement of the columns, since the coefficients of thermal expansion of steel and concrete are approximately equal.

### 8. *Tests*

In addition to the strict control exercised over the proportions and the gauging of the concrete, 6-inch cubes were frequently made and stored under conditions as nearly as possible identical with those governing the actual work of which they were samples, until the stipulated time of testing. As may be expected, this procedure resulted in considerable variations in the 7-day and 28-day strengths of similar concrete, according to the atmospheric conditions, but the Author attaches more value to the results so obtained than to those obtained by the more usual method of storing under "artificial" conditions.

One obvious advantage of curing test blocks *in situ* lies in the fact that breaking stresses determined from them, being more closely related to the actual strength of the concrete in the structure, may be used with greater confidence in determining permissible intervals between the casting of concrete and the stripping of its shutters. In the interests of progress and in fairness to the contractors, this interval should vary with the rate of development of the strength of the concrete, rather than depend upon a preconceived estimate of the minimum period necessary to conform with the requirements of safety under all conditions of curing.

The breaking stresses of the 6-inch cubes were as follows:

| | 6 to 1, Class 1 | | 6 to 1, Class 2 | | 5 to 1, Class 3 | |
|---|---|---|---|---|---|---|
| | 7 days lbs./sq.in. | 28 days lbs./sq.in. | 7 days lbs./sq.in. | 28 days lbs./sq.in. | 7 days lbs./sq.in. | 28 days lbs./sq.in. |
| Average | 2,650 | 3,586 | 2,251 | 3,600 | 3,028 | 4,531 |
| Maximum | 3,660 | 5,070 | 3,550 | 4,900 | 4,260 | 5,710 |
| Minimum | 1,710 | 2,490 | 1,160* | 2,165* | 1,950 | 3,645 |
| Specified minimum | 1,600 | 2,650 | 1,600 | 2,650 | 1,700 | 2,850 |

* These cubes were cured during an average air temperature below 32° F.

| | 5 to 1, Class 3 (Vibrated) | |
|---|---|---|
| | 7 days lbs./sq. in. | 28 days lbs./sq. in. |
| Average | 3,234 | 4,695 |
| Maximum | 4,740 | 5,470 |
| Minimum | 2,270 | 3,580 |
| Specified minimum | 1,700 | 2,850 |

Until the outbreak of war, cement bins were set aside by the makers for the job, samples being taken for test and the bins sealed until receipt of the order for release. Check tests upon the cement as delivered were taken from time to time.

Steel was tested from samples chosen at the mills.

The tests upon concrete blocks, cement and steel were carried out by the Industrial Research Laboratory of the City of Birmingham Gas Department.

The final tests for water-tightness were conducted after thorough hosing of walls and floors, and treatment with chloride of lime. When filled, readings of the water level were taken over a period of 40 days, revealing no measurable drop in water level after the first few days, during which absorption took place to a total amount equivalent to approximately one-third of a pint per square foot of wetted concrete area. In the meantime, periodical bacteriological tests were taken until self-purification, resulting from storage in the dark, produced a satisfactory result which justified bringing the reservoir into commission.

## Period for Completion

The specified contract time, commencing in May, 1938, was 2½ years, and the rate of progress up to the outbreak of war was such that, had it been possible to maintain it, the work would have been completed within the prescribed time.

The difficulties experienced in maintaining supplies of labour and materials on any but work of the highest priority are too well remembered to need recounting here but, together with the incidence of the severe winters of 1939-40 and 1940-41, they prolonged the work to a period of 4 years and 5 months, the final filling being completed in October, 1942.

## Cost

The contract price was £60,632, which was increased by war contingencies to a final cost of £65,307, equivalent to £3,644 per million gallons. The contractors were Messrs. William Moss & Sons, Ltd., of Loughborough and London.

## Quantities

The main quantities of materials, etc., were as follows:

| | |
|---|---|
| Concrete | 16,400 cubic yards |
| Steel reinforcement | 500 tons |
| Excavation | 86,300 cubic yards |

## Conclusion

Acknowledgments are due to Alderman Humphreys, Chairman of the City of Birmingham Water Committee, for permission to submit this Paper; and to Mr. R. C. Whitehead, B.Sc., A.M.I.C.E., and Mr. C. V. Green, B.Sc., A.M.I.C.E., both of whom were for some time resident upon the works, for their assistance in its preparation.

## MEMOIR OF ALMON L. FALES

Almon L. Fales, a member of the New England Water Works Association since 1914, died at his home in Newton Center, Mass., August 19, 1949, after an illness of several months.

Mr. Fales was born in Medway, Mass., January 6, 1876. He graduated from the Worcester Polytechnic Institute in 1898 with a degree of bachelor of science in chemistry. From 1898 to 1913 he was connected with the Sewage Purification Works of the city of Worcester, rising from assistant chemist to superintendent and director of testing laboratories. In 1913 he joined the consulting engineering firm of Metcalf & Eddy, Boston, from which he retired as an active partner in 1948 due to ill health. He retained his connection with the firm as a consultant until his death.

Mr. Fales was one of the country's leading authorities in the field of sanitary engineering, particularly in the fields of stream-pollution abatement, sewage purification and the treatment of industrial wastes. In both world wars he served the government in a consulting capacity, with respect to sewage-disposal methods at army camps and with respect to treatment of wastes from ordnance plants.

He was the author of many articles for the technical and scientific press. In addition to the New England Water Works Association, he belonged to the American Society of Civil Engineers, the Boston Society of Civil Engineers, the American Water Works Association, the American Chemical Society and the New England Sewage Works Association.

Mr. Fales was an active member of the First Congregational Church at Newton Center, of which he was Moderator for many years. He was a descendant of James Fales from Chester, England, who settled in Dedham in 1638.

He is survived by his wife, Clara Alice (Blood) Fales, and three daughters, Doris Edna Fales, Virginia Blood Fales and Marion Elizabeth (Fales) Dietz.

Mr. Fales was a man of sterling character, deeply devoted to his profession and most conscientious for the interest of his clients. Although his reputation was international, he was of a modest and retiring nature. Kindliness, courtesy and consideration for others were pre-eminent among his characteristics—characteristics sorely needed in a troubled world.

E. Sherman Chase

# PROCEEDINGS

## Sixty-eighth Annual Convention

## Dixville Notch, N. H.

September 13 to 16, 1949

The Sixty-eighth Annual Convention of the New England Water Works Association was held at The Balsams, Dixville Notch, N. H., on September 13 to 16, 1949.

### Tuesday, September 13

*Morning Session*

President Arthur C. King presiding.

The Annual Reports of the Secretary, Treasurer, Editor, Finance Committee, Committee on Legislation, Committee on Committees, Committee on Technical Program, Committee on Library and Committee on Membership were presented and accepted.

The following progress reports of technical committees were presented and accepted: Committee on Reinforced Concrete Pressure Pipe, Committee on Specifications for Steel Pipe, Committee on Gate Valve Specifications, Committee to Report on Developments in Our Knowledge of Corrosion and Its Mitigation, Committee on Laying Cast-Iron Water Mains, Hydrant Specification Committee and Committee on Meter Specifications.

An informal report was presented by the Committee on Specifications for Cast-Iron Pipe and Fittings. All formal reports are printed in this issue of the Journal.

Secretary Knox announced the election of the following to membership in the Association:

Roland F. Burke, Manager, Hartford Water Co., Lebanon, N. H.; Dexter O. Fisher, Senior Civil Engineer, Construction Division, Metropolitan District Commission, Boston, Mass.; Richard M. Heffernan, Foreman, Water Dept., North Reading, Mass.; George H. McDonnell, Manager, Tighe & Bond, Consulting Engineers, So.

Hadley Falls, Mass.; Walter M. Nagle, Water Commissioner, West Springfield, Mass.; Eric Schaefer, Chief Engineer, Quito Water Supply, Quito, Ecuador; Marshall R. Sharpe, Assistant New England Division Manager, Water Works Service Co., Skowhegan, Me.; David H. Turcotte, Chemist, Water Dept., Lowell, Mass.

*Reinstated:* James E. Fuller, Research Professor, Bacteriology, University of Massachusetts, Amherst, Mass.

*Corporate Member:* North Reading Board of Public Works, North Reading, Mass.

The President declared the polls closed and appointed as tellers John H. Robinson, Clarence B. French and Marshall S. Wellington.

*Afternoon Session*

A talk on "Casual Observations of English Water Works Practices" was given by E. Sherman Chase, Chairman, Committee on Reciprocal Relations with the Institution of Water Engineers (England).

A paper on "A National Roster of Sanitary and Public Health Engineers" was read by Francis B. Elder, Engineering Associate, American Public Health Association, New York, N. Y.

A talk on "Man-Power Versus Machine for Gate Operation," with illustrations and field demonstrations, was given by Payne Dean, of Payne Dean & Co., Madison, Conn.

Wednesday, September 14

*Morning Session*

An open forum was held on the subject of "Water-Works Operating Expenses under Post-War Conditions", Edgar H. Hunter acting as Moderator. Prepared papers by Frank A. Marston, Percy A. Shaw, Theodore L. Bristol and Edwin T. McDowell were read and several other members took part in the discussion.

A paper on "The Use of Dresser Couplings in Steel Transmission Mains" was read by Arthur S. Hicks, Dresser Manufacturing Division, Dresser Industries, Inc., New York, N. Y.

## Thursday, September 15

### *Morning Session*

A talk on "The Formation of Snow and Rain in the Atmosphere" was given by Vincent J. Schaefer, Research Laboratory, General Electric Co., Schenectady, N. Y.

A paper on "Iron and Manganese Removal in the Spaulding Precipitator" was read by Russell H. Babcock, Whitman & Howard, Boston, Mass.

A paper on "Diversion Damages Resulting from the Swift and Ware River Takings" was read by Walton H. Sears, Consulting Engineer, Arlington, Mass.

### *Afternoon Session*

A paper on "Mutual Interests between the Water Works and Atomic Energy Industries" was read by Arthur E. Gorman, Sanitary Engineer, Division of Engineering, U. S. Atomic Energy Commission, Washington, D. C.

A paper on "Modern Techniques in the Design of Concrete Mixes and the Method of Placing Concrete" was read by F. E. Votaw, District Engineer, Portland Cement Association, Boston, Mass.

A paper on "Observations on Water Samples from Cement-Asbestos Pipe Systems in Vermont" was read by Edward L. Tracy, Director, Division of Sanitary Engineering, State Board of Health, Burlington, Vt.

### *Evening*

Through the courtesy of the Water and Sewage Works Manufacturers Association a social hour was enjoyed in the Ten O'Clock Club, followed by a dinner in the main dining-room of the hotel.

## AWARD OF THE DEXTER BRACKETT MEMORIAL MEDAL

PRESIDENT KING. Each year there is presented an award for one of the papers presented during the previous year to this Association. At this time I shall call on the chairman of the committee on that award, William B. Duffy, to make the presentation of the Dexter Brackett Memorial Medal.

WILLIAM B. DUFFY. Mr. President, members and guests:

Thirty-three years ago the New England Water Works Association established the Dexter Brackett Memorial Medal. That was done to perpetuate the memory of Dexter Brackett, who for many years was connected with the water-works field. Mr. Brackett was with the Boston Water Department and later, when the Metropolitan Water System took over the Boston division, he became chief of the distribution division. Later he became Chief Engineer for the Metropolitan Water System. Mr. Brackett was Editor of the JOURNAL for some time and was president of the New England Water Works Association in 1889-1890. The medal was instituted because, in the words of Charles W. Sherman, of the committee appointed to formulate the Dexter Brackett Memorial Medal, Mr. Brackett was the foremost figure in the Association for many years and was as responsible as any single individual for the high quality of the programs produced for many years, when little was being done in that respect.

Since 1916—thirty-three years ago—28 members of the Association have received the award. Two members have received the award twice. They were Robert E. Horton and John R. Baylis. And one member, Caleb Mills Saville, has received it three times.

This year your committee, consisting of Horace L. Clark, Consulting Engineer of Sanford, Me., Donald W. Loiselle, of the Bridgeport Hydraulic Co., Bridgeport, Conn., and the speaker, were unanimously of the opinion that the most meritorious paper published in the JOURNAL in 1948 was that entitled "Emergency Water Supply for Rutland, Vermont, Following the Flood of June 3, 1947." The author, Edward L. Tracy, is one of Vermont's leading engineers.

He is a native Vermonter and the first member from Vermont who has received the Dexter Brackett Memorial Medal. Mr. Tracy is a registered professional engineer. He graduated from the University of Vermont in 1926 and since 1941 has been an instructor in public health at the University. He was employed as City Engineer and Commissioner of Public Health by the city of Rutland. Mr. Tracy has been Director of the Division of Sanitary Engineering of the Department of Public Health of the State of Vermont since 1939.

Mr. Tracy, it is a great pleasure and an honor for me, on behalf of the New England Water Works Association, to present to you the Dexter Brackett Memorial Medal for the year 1948.

EDWARD L. TRACY. Chairman Duffy, Mr. President, members and guests of the New England Water Works Association:

Your flattering remarks, Mr. Duffy, would distract me from my speech if I had prepared one. The appreciation which I feel for this honor that you people, through your Dexter Brackett Award Committee, are conferring on me is greater than I can express in words, and I can only say, "Thank you most sincerely". I am very happy to receive the award for myself, and also I am equally happy to bring it back to Vermont for the first time.

I was surprised as much as pleased and thankful, when I received the letter from Secretary Joe Knox telling me of the award. I had considered the article more or less a narrative account of the happenings of a few days and knew that it did not contain any of the informative tables, graphs or charts which we generally look for in engineering papers. However, if it has merit, I think it may possibly be the thought which ran through the article that none of us are very independent. Certainly in a time of great trouble we look for help from many of our friends and neighbors. Therefore, I should give credit to those water superintendents, to the manufacturers' representatives, and to the many others who were so helpful during those somewhat dramatic days following the Rutland flood, which was the basis for this paper.

So now let me say most sincerely, "Thank you."

## COMMEMORATIVE AWARD

PRESIDENT KING. For some little time it has been thought in the Association that we were rather stingy in our awards, making only the Dexter Brackett Award each year. At any rate, this year it was decided to make a second award, called the Commemorative Award. This award is made in memory of members who have been prominent in the several fields of the water-works profession—that is, in memory of a different member each year. This year the award is being made in memory of Fayette F. Forbes, who served the Water Department of Brookline, Mass., from 1878 up to his passing in 1935, at which time his capacity was that of superintendent of the department. He became a member of this Association in 1885, was elected its president in 1898, and in 1927 was elected to honorary membership. He wrote many papers, 15 of which were published in the JOURNAL of the Association. He was considered an expert on the subject of ground-water supply. Hence the selection of his name for the Commemorative Award of 1948, which is being made for the paper on "The Utilization of Electrical and Radioactivity Methods of Well Logging for Ground-Water Supply Development," by John J. Baffa, Consulting Engineer, New York, N. Y.

[To Mr. Baffa] It gives me great pleasure at this time to present you with your certificate and the award of books to accompany it.

JOHN J. BAFFA. Mr. King, members and guests of the New England Water Works Association:

I am indeed proud and happy to be the first recipient of the Commemorative Award, and I should like to regard it not as a personal honor but more as a symbol of coöperation, exemplifying the fact, mentioned by Mr. Tracy just a moment ago, that none of us are independent these days and, in the present state of the world, coöperation is essential.

As New York is beyond the borders of what is commonly considered New England, I should like to regard it as hands-across-the-

border in coöperation, which is essential in these days to preserve and guard our system of free enterprise, so well exemplified by the very great contributions that New England has made to the industry of our great country. Thank you, one and all, for this Commemorative Award.

* * *

Honorary membership in the Association was conferred upon the following members: Roger W. Esty, Superintendent, Water and Sewer Works, Danvers, Mass.; Harry U. Fuller, Chief Engineer (retired), Portland Water District, Portland, Me., and Timothy W. Good, Superintendent (retired), Water Department, Cambridge, Mass.

Twenty-five Year Certificates were awarded to the following members of the Association: Jacob A. Handy, Superintendent, Water Department, South Weymouth, Mass.; Arthur C. King, Superintendent, Water Works, Taunton, Mass., and William J. Lumbert, Superintendent, Water Department, Scituate, Mass.

Friday, September 16

*Morning Session*

A paper on "Operation and Maintenance of Pressure Filters" was read by Ernest E. Tankard, Superintendent, Water Works, Berlin, N. H.

A paper on "Telling the Public about Water-Works Systems", prepared by Martin E. Flentje, Research Engineer, American Water Works Co., New York, N. Y., was read by Edwin L. Jette, Local Manager, Mystic Valley Water Co., Mystic, Conn.

PRESIDENT KING. We shall now have the report of the Tellers of Election.

The report was read by Secretary Knox as follows:

REPORT OF THE TELLERS OF ELECTION

| | | |
|---|---|---|
| Total votes cast: | 278 | |
| For PRESIDENT: | Sidney S. Anthony | 272 |
| For VICE-PRESIDENTS: | Thomas R. Camp | 270 |
| | Frederick O. A. Almquist | 269 |
| For DIRECTORS: | Stanley M. Dore | 273 |
| | William B. Duffy | 270 |
| | Roger G. Oakman | 271 |
| For TREASURER: | William P. Melley | 275 |

(*Signed*) JOHN H. ROBINSON
CLARENCE B. FRENCH
MARSHALL S. WELLINGTON

PRESIDENT KING. I declare the persons named elected for the ensuing year.

According to the Constitution, the president is required and instructed to present an address at this time.

## PRESIDENTIAL ADDRESS

BY ARTHUR C. KING

Every business of any considerable size takes an inventory at least once each year, in order to determine the progress or profits actually made during the year. So too, it seems fitting that our Association should give some thought, at the closing of this, our Sixty-eighth Annual Convention, to the condition of the water-works industry in general, as well as to our own progress as a group.

Again this summer, record-breaking heat and severe drought in New England, with the accompanying large use of water, so depleted the water supply of many communities that rigid restrictions were enforced to conserve what water was available. To me this constitutes failure to perform the service that we purport to render, in that water was not available for the customary uses, even though the amount desired was abnormal. Should we not expect and plan for abnormal conditions, to the limit of our resources? I believe most

water-works men do that very thing—to the limit of their resources. But how about raising the limit? Are we giving enough consideration and work to that end, since to most of us the most limited of our resources is the financial limit? Let us consider for a moment what might be done.

Some water-works organizations, private companies, districts and some municipally-owned systems, which have full control of their receipts, have one remedy for limitation of funds—that is, increased rates. There will be objection of course, but even so water will still be the cheapest thing we buy. Many municipally-owned systems, however, are under a different kind of limitation. No matter how great their receipts, they are permitted to use only enough, or less than enough, for bare necessities. All surplus may be diverted to other municipal use. This condition is not confined to New England, by any means. All over the country water-works men are pondering and discussing this problem of how to stop or lessen diversion of water-works revenue, when it is needed for maintenance or improvement of the water systems. This kind of limitation is beyond the direct control of the water-works men and is in the hands of the finance officers, or the politicians, of the municipality.

In 1948, this Association sponsored a petition to the Massachusetts General Court, asking that a bill be enacted to prohibit or curtail diversion of water revenue. It was hoped that enactment of this bill might serve as an example and a precedent for similar action in other states. The petition was referred to a special commission for study and recommendation to the 1949 session. The commission's recommendations were favorable but the legislature acted unfavorably.

I hope that further effort will be made to overcome the opposition and secure passage of a similar bill, for surely prohibiting diversion of funds would make for the betterment of water systems, and water, after all, is the one essential to life for which there is no substitute. At the same time, the long-term effect on municipal finances would be beneficial, by the reduction in interest charges on bond issues. It is admitted that the immediate effect might be some increase in tax rates for a short time after adoption of the plan. There is a challenge here to accomplish much good by an educational and political campaign.

This thought leads to another which has a bearing on the problem. This is the modesty and self-effacement of too many water-works men. We need to be better press agents for ourselves and for our work.

There is an old adage, "Out of sight is out of mind", and this phrase applies to nothing more accurately than to water systems and their needs. It is unfortunate that it takes a serious failure of service, whether from breakdown of machinery and structures or from scarcity of water, to make most citizens realize that they are absolutely dependent upon an unseen and almost forgotten system. It is surprising too how quickly their helpless feeling at the time of a breakdown is replaced by "It won't happen again."

To counteract this apathy, we need to increase or intensify our public-relations program—keep the citizens conscious of their water system by publicity—and personally I care little whether it is praise or blame about the system, so long as the personnel is doing its best with what it has. Criticism, whether justified or not, may stir up sentiment enough to bring some action by the authorities who control the purse strings.

In other words we need to be better salesmen and talk water-works needs at every opportunity that is offered or can be made. Service Clubs, Women's Clubs, Community Forums, Granges, Men's Clubs in Churches and others are always looking for speakers and we can interest them in the story of their water supply and its needs, which can always be brought out. The facts must be broadcast as widely as possible, both as to defects and as to remedies. Strongly aroused public sentiment can accomplish wonders.

Now to review the condition of this Association briefly. The reports of the Secretary, the Treasurer and the Editor have given you in detail the figures on our membership, finances and publication. Suffice it to say here that our Association is in good condition in all those respects, but I do wish to add a word about our newer members. It is a fine thing to have so many of the younger water-works men joining. Their interest, activity and enthusiasm will benefit the Association, and Association membership will benefit them. There are still many more men who should be receiving and giving these benefits. Let each of us see to it that our neighbors realize the value of membership in our organization.

The attendance at meetings has been gratifying, the number at the May meeting at Quabbin Reservoir greatly exceeding that at any previous one-day meeting. The average number at regular Boston meetings has been about 15% above that of a couple of years ago.

Stanley M. Dore, who has served faithfully and well for several years as Chairman of the Committee on Technical Program, desired to be relieved of this duty and we were fortunate in procuring Truman H. Safford to carry on with fresh contacts and enthusiasm. Our regular committee activities have continued with little change in personnel, but I wish particularly to mention the special committees selected to plan and arrange our out-of-Boston meetings in April, May and June and this Convention. It is no small task to take care of all the details which make for the success of those meetings. These committees did yeoman work.

I doubt if many members realize the extent to which the success of our meetings, as well as the smoothness of operation of our Conventions and the Association business, are the result of the painstaking care, the constant thought and the work of our Secretary, Joseph C. Knox, most effectively aided by Mrs. Alice R. Melrose, Assistant Secretary. Without them, a President would find himself in many an unexpected dilemma.

To them and the members of the committees previously mentioned I extend hearty and sincere thanks, nor would I omit mention of the officers and other members of the Executive Board, from whom I have received the finest coöperation and support. Our association throughout the year has been most pleasant.

We are indebted to the officers and members of the Water and Sewage Works Manufacturers' Association for much that they have added to the social side of our activities and we assure them of our appreciation.

In conclusion, I can only say that it has been a pleasure and an honor to serve as your President, and I greatly appreciate your cooperation and your indulgence of my shortcomings.

It now becomes my duty and my pleasure to present your President for the ensuing year, Sidney S. Anthony of Augusta, Me.

PRESIDENT ANTHONY. I just want to express my sincere and deep gratitude to the Association for having elected me to this office,

and I pledge my best efforts and hope that I shall be able to keep up with the record set by my predecessors in this office. You will probably hear from me later on about committees. I thank you.

The program says that the final item of business of the convention is the introduction of the new president. Now that has been done I can see no point in staying around any longer, unless somebody has something else to take up.

E. SHERMAN CHASE. I have one thing to bring up that I ought to have brought up the other day in my report on Reciprocal Relations, and with your indulgence I should just like to call it to the attention of the hardy souls who have stuck it out to the end.

You may know—I think you all do know—that the American Water Works Association is getting out a new manual on Water Works Practice, which every member of this Association ought to buy when it is available. You probably do not know that the Institution of Water Engineers is getting out another manual, primarily relating to the British practice, which some of you—not all of you—ought to acquire when it does come out. As I am an American correspondent for the Institution of Water Engineers, Mr. Hobbs asked me to pass the information along to the people in New England, and I am just fulfilling what I was told to do. Anyone who feels that he would like to get this manual when it is published—if he will let me know, I shall see that his order is transmitted to Mr. Hobbs.

THOMAS R. CAMP. How much will it cost?

MR. CHASE. They estimate it will cost about $8.50. It is going to be a big volume, about 900 pages—a real treatise.

PRESIDENT ANTHONY. Is there anything further?

On motion duly made and seconded, it was VOTED to adjourn.

## ANNUAL REPORT OF THE SECRETARY

*Mr. President and Gentlemen of the New England Water Works Association:* The Secretary herewith submits the following report of the changes of membership during the past fiscal year and the general condition of the Association.

The present membership is 922, constituted as follows: 13 Honorary Members, 755 Members, 3 Juniors, 119 Associate Members and 32 Corporate Members.

MEMBERSHIP

| | | | Total |
|---|---|---|---|
| September 1, 1948—Honorary Members, Total | | 10 | |
| Elected: | | | |
| March 17, 1949 | 1 | | |
| May 19, 1949 | 1 | | |
| June 29, 1949 | 1 | 3 | 13 |
| September 1, 1948—Members, Total | | 739 | |
| Withdrawals: | | | |
| Resigned | 12 | | |
| Died | 11 | | |
| Dropped by the Executive Committee | 9 | 32 | |
| Transferred to Honorary Membership | | 3 | 704 |
| Elected: | | | |
| September 14, 1948 | 13 | | |
| October 21, 1948 | 2 | | |
| November 18, 1948 | 6 | | |
| January 20, 1949 | 3 | | |
| February 17, 1949 | 7 | | |
| March 17, 1949 | 8 | | |
| April 21, 1949 | 3 | | |
| May 19, 1949 | 4 | | |
| June 29, 1949 | 4 | | |
| Junior Members elected Dec. 16, 1948 | 2 | | |
| Reinstated as members: | | | |
| October 21, 1948 | 1 | | |
| December 16, 1948 | 1 | 54 | 758 |

| | | | | |
|---|---|---|---|---|
| September 1, 1948—Associates, Total | | 118 | | |
| Withdrawals: | | | | |
| Resigned | 5 | 5 | 113 | |
| Elected: | | | | |
| September 14, 1948 | 2 | | | |
| March 17, 1949 | 1 | | | |
| May 19, 1949 | 2 | | | |
| June 29, 1949 | 1 | | 6 | 119 |
| September 1, 1948—Corporates, Total | | 31 | | |
| Elected: | | | | |
| September 14, 1948 | 1 | 1 | | 32 |
| September 1, 1949—Total Membership | | | | 922 |
| September 1, 1948—Total Membership | | | | 898 |
| Net Gain | | | | 24 |

## ELECTIONS

### *Members*

September 14, 1948—Russell H. Babcock, James E. Barry, Walter M. Bussolari, Jr., Wilfred C. Gilbert, James D. Halwartz, Arthur S. Hicks, Frank W. Melcher, George F. Miller, Leopold J. Paradis, Edward J. Pinkul, Martin J. Shaughnessy, John P. Sullivan and Henry C. Whitlock. (13)

October 21, 1948—Theodore V. Berry and Francis J. Lariviere. (2)
Reinstated: Frederick G. Penniman. (1)

November 18, 1948—George J. Coogan, Gerard J. Gaynor, Henry J. Hunt, Charles H. Lawrence, Russell F. Ruhp and Chester R. Spielvogel. (6)
Junior members: Sumner J. Weinstein and Richard S. Woodhull. (2)

January 20, 1949—Herman Burgi, Jr., Lloyd W. Nelson and Harold T. Smith. (3)

February 17, 1949—Nathaniel Clapp, Arthur L. Dopmeyer, Martin J. Markham, Minot P. Secord, Matthew D. Sullivan, Edwin J. Titsworth and Leonard H. White. (7)

March 17, 1949—Nathan S. Bubbis, Wilbur H. Dewey, Charles A. Duffy, Ernest H. Ebert, Charles Y. Hitchcock, Jr., Richard J. Kelley, Albert P. McCann and Chester H. Minehan. (8)

April 17, 1949—Albert H. Cooper, Peter Pryharski and Thomas J. Quigley. (3)

May 19, 1949—Sebastian Cali, Norman D. Hall, Joseph V. Hanbury and James C. M. Tillinghast. (4)

June 29, 1949—Nicholas J. Callahan, John W. Copithorne, Robert V. Cushman and James A. White. (4)

*Associate Members*

September 14, 1948—The Permutit Company and Smith-Blair, Inc. (2)
March 17, 1949—General Painting and Maintenance Corporation. (1)
May 19, 1949—H. F. Davis Tractor Company and Hilco Supply. (2)
June 29, 1949—Chemical Fire & Rust Proofing Corporation. (1)

*Corporate Members*

September 14, 1948—The Avon Water Company. (1)

WITHDRAWALS

*Members*

Resigned: Boyd A. Bennett, Charles E. Burrill, Charles W. Easter, Calvin K. Glover, Hugh J. Loughlin, Herbert D. Morrison, Ernest D. Mortenson, Edward J. Murphy, Albert A. Ross, Clyde B. Rowntree, Burton L. Winslow and G. Lawrence Winslow. (12)

Died: Frederick W. Bateman, Ernest B. Black, Philip E. Bond, Arthur R. G. Booth, Louis B. Davis, Almon L. Fales, Daniel W. Mead, Oren M. Moulton, W. H. Powell, Roy W. Smith and Ernest J. Sullivan. (11)

Dropped by the Executive Committee: John F. Finn, George B. Garrett, Jr., Thomas E. Hegarty, William E. Hogan, Russell L. MacDonald, James E. Shurtleff, Thomas W. Speight, Jr., Thomas D. Walsh and Herman E. Warner. (9)

*Associates*

Resigned: Darco Corporation, The Foxboro Company, Inertol Company, Johnson-Barker and Webb Company and Johnston & Jennings Divn. (5)

RECEIPTS FOR THE FISCAL YEAR SEPTEMBER 1, 1948, TO SEPTEMBER 1, 1949

| | |
|---|---|
| Entrance Fees | $ 183.00 |
| Dues of Members of all grades | 7,148.50 |
| Dividends | 500.36 |
| Advertisements | 5,370.50 |
| Subscriptions | 632.50 |
| Journals | 72.40 |
| Membership Certificates | 41.50 |
| Total Receipts | $13,948.76 |
| There is due the Association: | |
| Dues | 130.00 |
| Advertising | 158.00 |
| Total | $14,236.76 |

Respectfully submitted,

(*Signed*) JOSEPH C. KNOX, *Secretary*

## ANNUAL REPORT OF THE TREASURER

Boston, September 7, 1949

*To William P. Melley, Treasurer,*
*New England Water Works Association,*
*Boston, Massachusetts.*

We have examined the statement of assets and funds and the statement of cash receipts and disbursements of the general fund of the New England Water Works Association for the year ended August 31, 1949. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

We traced all recorded receipts into the depositary bank, verified the general fund bank account and petty cash fund as at August 31, 1949, and examined properly approved vouchers for all disbursements. We also verified by direct communication the investment funds on deposit in savings and coöperative banks, and on September 1, 1949, we examined the United States Treasury savings bonds at the First National Bank of Boston.

In our opinion, the accompanying statement of assets and funds and the note thereon and the related statement of cash receipts and disbursements of the general fund present fairly the financial position of the New England Water Works Association at August 31, 1949, and the recorded cash receipts and disbursements for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(*Signed*) SCOVELL, WELLINGTON & COMPANY

STATEMENT OF ASSETS AND FUNDS (Exhibit A)

As at August 31, 1949

*Assets*

| | | |
|---|---|---|
| Cash in banks, invested funds | | |
| Farmers and Mechanics Savings Bank, Framingham, Massachusetts | $ 1,068.46 | |
| Franklin Savings Bank, Boston, Massachusetts | 1,000.00 | |
| Haverhill Savings Bank, Haverhill, Massachusetts | 1,000.00 | |
| Home Savings Bank, Boston, Massachusetts | 1,000.00 | |
| Mechanics Savings Bank, Reading, Massachusetts | 1,000.00 | |
| Pentucket Savings Bank, Haverhill, Massachusetts | 1,000.00 | |
| The People's Savings Bank, Worcester, Massachusetts | 1,000.00 | |
| Suffolk Savings Bank, Boston, Massachusetts | 1,000.00 | $8,068.46 |
| Securities | | |
| U. S. Treasury savings bonds G 2 1/2s, 1954 | $10,000.00 | |
| 25 shares Milton Co-operative Bank, series of June, 1940 | 3,280.50 | 13,280.50 |
| Total invested cash and securities | | $21,348.96 |
| General fund | | |
| Cash, First National Bank of Boston | $ 4,847.67 | |
| In office | 50.00 | |
| | $ 4,897.67 | |
| Furniture and fixtures | 1,180.00 | 6,077.67 |
| | | $27,426.63 |

*Funds*

| | | |
|---|---|---|
| Invested funds | | $21,348.96 |
| General fund | | |
| Balance, August 31, 1948 | $ 6,650.62 | |
| Less Purchase of Milton Co-operative Bank shares | 300.00 | |
| | $ 6,350.62 | |
| Excess of disbursements over receipts, Exhibit B | (272.95) | |

| | |
|---|---|
| Balance, August 31, 1949 | 6,077.67 |
| | $27,426.63 |

Note: The statement above, prepared on a cash basis, includes dues received in advance, $3,092.50, and employees' withholding tax, $86.79. It does not reflect the following:

| | |
|---|---|
| Accounts receivable, dues | $ 130.00 |
| Due on account of advertising | 158.00 |
| | $ 288.00 |

No depreciation has been taken on furniture and fixtures.

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS (Exhibit B)

*General Fund*

For the Year ended August 31, 1949

| | | | |
|---|---|---|---|
| Receipts (exclusive of dues received in advance and employees' withholding tax) | | | |
| Initiation fees | | $ 183.00 | |
| Dues, 1948-49 and prior years | | 4,056.00 | |
| Interest | | 500.36 | |
| From publication of Journal | | | |
| Advertisements | $5,370.50 | | |
| Subscriptions | 632.50 | | |
| Sale of Journal | 72.40 | 6,075.40 | |
| Miscellaneous | | | |
| Membership certificates | | 41.50 | |
| Total Receipts | | | $10,856.26 |
| Disbursements | | | |
| Publication of Journal | | | |
| Printing | $3,284.11 | | |
| Plates | 371.21 | | |
| Reprints | 207.96 | | |
| Reporting | 239.92 | | |
| Stationery and postage | 134.22 | | |
| Editor's salary | 750.00 | | |
| Sundry | 29.02 | $5,016.44 | |

| | | | |
|---|---|---|---|
| General and administrative | | | |
| Certificates of membership | $ 165.20 | | |
| Secretary's salary | 750.00 | | |
| Assistant to secretary—salary | 2,534.00 | | |
| Treasurer's salary | 200.00 | | |
| Printing, postage and stationery | 208.06 | | |
| Office supplies and expense | 431.18 | | |
| Office rent | 1,020.00 | | |
| Electricity | 93.01 | | |
| Telephone and telegraph | 264.45 | | |
| Auditing | 85.00 | | |
| Social security taxes | 57.34 | | |
| Sundry | 67.67 | 5,875.91 | |
| Meetings and committees | | | |
| Water works school | $ 125.00 | | |
| Printing, postage and stationery | 1,324.61 | | |
| Convention expense | 669.41 | | |
| Dinners | 790.07 | | |
| Contribution to June conference | 150.00 | | |
| Sundry expense | 204.68 | 3,263.77 | |
| Interest added to co-operative bank shares | | 94.00 | |
| Total Disbursements | | | $14,250.12 |
| Excess of disbursements over receipts (exclusive of dues received in advance and employees' withholding tax for current year) | | | $ 3,393.86 |
| Dues received in advance | | $3,092.50 | |
| Employees' withholding tax | | | |
| Receipts for current year | $86.79 | | |
| Less payment for prior year | 58.38 | 28.41 | 3,120.91 |
| Excess of disbursements over receipts, Exhibit A | | | ($272.95) |
| Balance, general cash, August 31, 1948 | | $5,470.62 | |
| Less purchase of Milton Co-operative Bank shares | | 300.00 | 5,170.62 |
| Balance, general cash, August 31, 1949 | | | |
| Represented by | | | |
| Cash in First National Bank of Boston | | $4,847.67 | |
| Cash in office | | 50.00 | |
| | | | $4,897.67 |

## ANNUAL REPORT OF THE EDITOR

*To the New England Water Works Association:*

The Editor submits herewith his report for the year ending August 31, 1949.

As has been customary in the past, the tables of financial figures, accompanying the report, are based upon total charges and accounts receivable, rather than actual cash received and disbursed. A detailed statement of the receipts and disbursements on account of the September and December, 1948, and March and June, 1949, issues of the JOURNAL is included in the report of the Treasurer.

In Table 1 is presented a statement of the material contained in the four issues of the JOURNAL for the past year, while in Table 2 is given a comparison of the JOURNAL for the past year with those for preceding years.

TABLE 1.—STATEMENT OF MATERIAL IN SEPTEMBER AND DECEMBER, 1948, AND MARCH AND JUNE, 1949, ISSUES OF THE JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION

| | Papers | Proceedings* | Total text | Index | Advertisements | Cover and contents | Insert plates | Total pages | Total cuts |
|---|---|---|---|---|---|---|---|---|---|
| Sept., 1948 | 72 | 50 | 122 | 0 | 44 | 4 | 0 | 170 | 15 |
| Dec., 1948 | 10 | 112 | 122 | 9 | 44 | 4 | 0 | 179 | 3 |
| Mar., 1949 | 102 | 3 | 105 | 0 | 45 | 4 | 4 | 158 | 17 |
| June, 1949 | 70 | 33 | 103 | 0 | 46 | 4 | 1 | 154 | 8 |
| Total | 254 | 198 | 452 | 9 | 179 | 16 | 5 | 661 | 43 |

*Including standard specifications and recommended practice.

*Size.* The four issues contained 661 pages, of which 452 were text.

*Cost.* The gross cost of the JOURNAL was $5,016.44, equivalent to $5.55 per member; the surplus was $1,058.96, equivalent to $1.17 per member.

*Reprints.* Reprints of papers have been furnished to authors at cost.

TABLE 2.—COMPARISON OF JOURNALS OF THE NEW ENGLAND WATER WORKS ASSOCIATION
Four Issues for Fiscal Year Ending August 31

| | 1940 | 1941* | 1942** | 1943*** | 1944 | 1945 | 1946 | 1947 | 1948‡ | 1949‡‡ |
|---|---|---|---|---|---|---|---|---|---|---|
| Average edition (copies printed) | 1,100 | 1,100 | 1,100 | 1,175 | 1,200 | 1,200 | 1,200 | 1,275 | 1,350 | 1,325 |
| Average membership | 796 | 800 | 803 | 798 | 799 | 806 | 820 | 846 | 876 | 905 |
| Circulation at end of year | 967 | 943 | 982 | 969 | 1,015 | 1,032 | 1,042 | 1,083 | 1,129 | 1,164 |
| Pages of text | 565 | 540 | 575 | 442 | 442 | 438 | 391 | 428 | 411 | 452 |
| Pages of text per 1,000 members | 710 | 675 | 716 | 554 | 553 | 543 | 477 | 516 | 469 | 500 |
| Total pages, all kinds | 762 | 733 | 757 | 616 | 621 | 630 | 586 | 632 | 615 | 661 |
| Total pages per 1,000 members | 957 | 918 | 943 | 772 | 777 | 782 | 715 | 747 | 702 | 731 |
| GROSS COST: | | | | | | | | | | |
| Total | $3,846.46 | $4,415.00 | $4,053.47 | $4,234.68 | $3,406.48 | $3,734.19 | $4,053.08 | $4,193.60 | $4,239.64 | $5,016.44 |
| Per copy | 0.87 | 1.00 | 0.93 | 0.90 | 0.71 | 0.78 | 0.84 | 0.82 | 0.78 | 0.95 |
| Per page | 5.05 | 5.66 | 5.36 | 6.87 | 5.49 | 5.83 | 6.91 | 6.63 | 6.90 | 7.60 |
| Per member | 4.33 | 5.52 | 5.05 | 5.31 | 4.26 | 4.63 | 4.94 | 4.96 | 4.84 | 5.55 |
| Per member per 1,000 pages | 6.34 | 7.53 | 6.67 | 8.61 | 6.87 | 7.35 | 8.43 | 7.85 | 7.87 | 8.40 |
| Per member per 1,000 pages of text | 8.55 | 10.21 | 8.78 | 12.01 | 9.66 | 10.57 | 12.62 | 11.58 | 11.78 | 12.28 |
| SURPLUS: | | | | | | | | | | |
| Total | $618.37 | $276.54† | $534.72† | $609.81† | $407.21 | $455.57 | $162.33 | $913.91 | $1,990.81 | $1,058.96 |
| Per copy | 0.14 | 0.06† | 0.12† | 0.13† | 0.08 | 0.09 | 0.03 | 0.18 | 0.37 | 0.20 |
| Per page | 0.81 | 0.38† | 0.71† | 0.99† | 0.66 | 0.72 | 0.28 | 1.44 | 3.32 | 1.60 |
| Per member | 0.78 | 0.35† | 0.67† | 0.76† | 0.51 | 0.57 | 0.20 | 1.08 | 2.28 | 1.17 |
| Per member per 1,000 pages | 1.02 | 0.47† | 0.88† | 1.24† | 0.82 | 0.90 | 0.34 | 1.71 | 3.71 | 1.77 |
| Per member per 1,000 pages of text | 1.37 | 0.64† | 1.16† | 1.73† | 0.92 | 1.29 | 0.51 | 2.52 | 5.55 | 2.59 |

* Including comprehensive index, 1882 to 1939, and 102 pages of standard specifications.
** Including 45 pages of standard specifications.
*** Including 28 pages of standard specifications.
‡ Including 54 pages of standard specifications.
‡‡ Including 107 pages of standard specifications and recommended practice.
† Net cost.

*Circulation.* The present circulation of the JOURNAL is:

| | |
|---|---|
| Members, all grades | 922 |
| Subscribers | 155 |
| Exchanges | 25 |
| Advertisers | 62 |
| Total | 1,164 |

JOURNALS have been sent to all subscribers and to advertisers.

Respectfully submitted,

(*Signed*) GEORGE C. HOUSER,
*Editor*

## ANNUAL REPORT OF THE FINANCE COMMITTEE

August 31, 1949

*To the Executive Committee of the New England Water Works Association*

Gentlemen:

Your Finance Committee herewith presents its report on the budget for the year 1948-1949 and its recommended budget for the year 1949-1950.

The following tables show the estimated and actual budget figures for 1948-1949:

REVENUE FOR 1948-1949

| | Budget | Actual to Aug. 31 | Difference |
|---|---|---|---|
| Initiation fees | $ 200.00 | $ 183.00 | $ 17.00 deficit |
| Dues | 6,500.00 | 7,148.50 | 648.50 surplus |
| Interest and dividends | 400.00 | 500.36 | 100.36 surplus |
| Journal | 6,200.00 | 6,075.40 | 124.60 deficit |
| Miscellaneous | 100.00 | 41.50 | 58.50 deficit |
| Total | $13,400.00 | $13,948.76 | $ 548.76 surplus |

DISBURSEMENTS FOR 1948-1949

| | Budget | Actual to Aug. 31 | Difference |
|---|---|---|---|
| General and administrative | $ 6,300.00 | $ 5,941.50 | $ 358.50 surplus |
| Journal | 4,500.00 | 5,016.44 | 516.44 deficit |
| Meetings and committees | 3,200.00 | 3,263.77 | 63.77 deficit |
| Contingencies | 1,000.00 | | 1,000.00 surplus# |
| Total | $15,000.00 | $14,221.71 | $ 778.29 surplus |

The estimated deficit was $1,600.00 and the actual deficit was $272.95. The reserve on hand August 31, 1949, amounts to $27,376.63.

# Of this $1,000 surplus, $580.21 was used to meet the deficits under the items Journal and Meetings.

There was a gratifying increase of $499.00 in dues over last year, which means that more members paid their dues on time, as the gain in membership of 24, as against 33 last year and 39 the year before, would not wholly account for the increase. Under the item "interest and dividends," the increase is due to the inclusion of interest on coöperative bank shares, on the recommendation of the Auditors.

The decrease in revenue under "Journal" was due largely to advertising losses.

Under Disbursements, the surplus under the item "general and administrative" is due in large part to efficient buying and office management. The deficit under the item "Journal" was due to increased printing costs—mainly special plates for illustrations and reprints of A.W.W.A. specifications.

Inasmuch as present economic conditions show no sign of becoming stabilized, we recommend continuing the policy of an unbalanced budget inaugurated in 1946.

BUDGET FOR 1949-1950

| | |
|---|---|
| *Revenue* | |
| Initiation fees | $ 175.00 |
| Dues | 6,800.00 |
| Interest and dividends | 500.00 |
| Journal | 6,000.00 |
| Miscellaneous | 50.00 |
| Total | $13,525.00 |
| *Disbursements* | |
| General and administrative | $ 6,000.00 |
| Journal | 5,000.00 |
| Meetings and committees | 3,200.00 |
| Contingencies | 500.00 |
| Membership list | 500.00 |
| Total | $15,200.00 |
| Deficit | $ 1,675.00 |

As may be seen in the above figures of the new budget, the revenue items follow very closely the actual amounts for the last

year with the exception of dues, which we have set up as an average of the last two years. The first and second disbursement items are also similar to those of last year.

Under the item "meetings," there was some discussion about the amount that the Association has been paying for members' lunches at the monthly meetings, being the difference between the actual cost and the price of the ticket. It was finally decided to continue this practice. It should be noted here that the cost of the ticket includes rental of the rooms where the meetings are held.

The "contingency" item was cut from $1,000 to $500 and an additional item was added for compiling and printing a new membership list, as the last one was printed in 1946 and is now very much out-of-date.

We refer you to the Treasurer's report for further financial details and to the Secretary's report for the changes in the membership roster.

Respectfully submitted,

*(Signed)* KENNETH W. ROBIE, *Chairman*
JOHN B. KENNEDY
HOWARD C. MANDELL

## ANNUAL REPORT OF THE COMMITTEE ON LEGISLATION

September 13, 1949

*To the New England Water Works Association:*

Your Committee on Legislation herewith presents its report on activity in the legislatures of the New England states during 1949.

Regular sessions were held in each of the six states; consequently this report will cover them all.

Connecticut reports that no important legislation bearing on water-works matters was enacted, but that a number of bills, presented during the session, developed strenuous opposition and failed of passage.

The Maine legislature at its recent session enacted the following:

#1. Increased the fee that utilities must pay for the opening of streets.
#2. Authorized the Public Utilities Commission to advise Water Utilities on proposed systems of Water Supply.
#3. Strengthened the existing law concerning the pollution of rivers.
#4. Added to the State Retirement Plan certain employees of sub-divisions of the State not previously covered.

In Massachusetts the Special Commission, authorized under Chapter 35 of the Resolves of 1948 to study the matter of Water Department financing, reported as Senate Bill #600 of 1949. In connection with Senate #600, the Committee on Water Supply of the legislature reported favorably in Senate #667, which was entitled "An Act regulating the use of water revenues in cities and towns", and read "No money from water rates, assessments, rentals, service charges or other income of the water works in any city or town having a water supply or water distributing system established under authority of this chapter (Chapter 40 of the General Laws), or under any special law, shall be used for any purpose other than water purposes, including water debt and interest". This legislation, after considerable debate in the Senate, failed of passage by a rather close margin. In further connection with Senate #600, the Committee on Water Supply reported favorably in Senate #666, which is a Resolve providing for a further investigation of this

matter by a Special Commission. This Resolve was enacted as Chapter 70 of the Resolves of 1949, and directs the Special Commission to report to the legislature on the subject the first Wednesday of December in the current year. In view of the progress made to date in the matter of this legislation, which your committee originally sponsored as directed by the Executive Committee, there appears to exist reasonable ground for hope of future favorable action. Most certainly our past efforts to obtain enactment of this legislation have received the enthusiastic support of the water-works men throughout the state, and we trust that such support will continue in the future.

In Massachusetts also, there was enacted into law Chapter 793, entitled "An Act authorizing Municipalities, Water Supply, Fire and Water Districts and Water Companies to restrain the use of water during an emergency". This amendment to Chapter 40 of the General Laws provides for the immediate protection of the public health, welfare and safety (when, in the opinion of the Department of Public Health, an emergency exists in the form of drought, hurricane, conflagration or other disaster), by authorizing water-supply officials, after due notification, to restrain the use of water by shutting off with appropriate means on public and private premises.

The General Court of the State of New Hampshire enacted during its 1949 session Chapter 271, entitled "An Act in relation to municipal utilities", section #1 of which reads as follows:

> "Public Service Commission. Before any town, village district or precinct shall vote to appropriate money or issue bonds or notes for the acquisition of any existing public utility, or for the construction of a public utility, or for the reconstruction or enlarging of a municipally owned utility, the selectmen of the town or the commissioners of the village district or the commissioners of any precinct may submit, and upon written application of fifty or more qualified voters or one fourth of the qualified voters of said town, district or precinct, shall submit to the public service commission the general details of the plan and the amount proposed to be expended together with engineering plans and specifications."

The Act further provides for a public hearing, in addition to an investigation by the Commission as to the public need for the project, with a final reading of the findings of said body to the town, village district or precinct meeting, within thirty days of the public hearing and previous to any voting on the matter by the interested group.

Our report from the State of Rhode Island advises that no legislation was enacted at the 1949 General Assembly having a bearing on activities in the water-works field.

Activity in the 1949 Vermont legislature resulted in passage of the following laws and amendments bearing some relation to water works:

Act 83. AMENDING VERMONT STATUTE, 3831, RELATING TO MUNICIPAL WATER SUPPLY CONSTRUCTION. Provides for acquiring, constructing and maintaining wells, reservoirs, ponds, springs, streams, real estate, easements, pumping facilities, etc. The method, by which a municipality may take, acquire or purchase rights and properties of a private water company, is clarified. Before a privately owned utility company can sell its assets, there must be a State Public Service Commission hearing which shows that the sale will promote the general good of the state.

Act 17. AMENDING VERMONT STATUTE 654 RELATING TO MUNICIPAL CORPORATIONS. The law formerly provided for the taxation of land owned by a municipality, but located outside its corporate limits, by the town or municipality in which the land is located. The revised law permits the taxation of land and buildings. The land must be assessed at the value set in the last previous quadrennial appraisal. Subsequent appraisals must be at the same rate per acre as similar property in the town. Improvements made after acquiring the property shall not be taxed, except that an additional tax, not to exceed 75% of the land value, may be levied in lieu of a personal property tax.

Legislation was passed which improves the status of municipal employees from the pension standpoint in Acts #12 and #81.

An Act (#148), authorizing the State of Vermont to become a member of the New England Water Pollution Control Commission and amending certain statutes in relation to the pollution of waters, was passed.

Act 39. PROVIDES FOR CONSTRUCTION OF NEW PUBLIC HEALTH LABORATORY IN BURLINGTON. This is important to all water-supply systems in Vermont, because the state laboratory takes care of analyses for all municipalities, private water companies and individuals in Vermont. The only municipality or water company with its own laboratory is the City of Burlington.

Respectfully submitted,

*(Signed)* MARK F. CROKER, *Chairman*
THEODORE L. BRISTOL
WALTER C. CONROY
PHILIP J. HOLTON, JR.
G. ARTHUR FANEUF
HARRY U. FULLER
EDWARD L. TRACY

## ANNUAL REPORT OF COMMITTEE ON COMMITTEES—1949

*To the New England Water Works Association:*

This committee, appointed by the Executive Committee of the Association to promote coördination of committee activities in the Association and to promote the establishment of new technical committees where this seems advisable, submits its report. Our committee has followed its usual practice of communicating with the various committee chairmen to ascertain their ideas as to continuance of committees and their plans with regard to reports. We have also been in touch during the year with other associations regarding joint committees. The Technical Program Committee has been advised as to those committees desiring to submit reports at the annual meeting.

Inactive committees should be dispensed with. There are some joint committees with other associations, however, dealing with preparation and approval of certain standards, where progress may be unavoidably slow in getting out reports. In writing to committee chairmen this year, this committee stressed the desire of the Executive Committee to weed out inactive committees.

During the year, no new committees were appointed by the Executive Committee. Some changes were made, as usual, in committee membership, as noted in the December, 1948, JOURNAL of the Association.

Listed below are committees which, in the opinion of this committee, should be continued, together with some notations as to activities where information is available through the committee chairmen. In the case of most of the following committees, the committee chairmen have expressed the opinion that the committees should be continued:

*Committee on Technical Program.
*Committee on Finance.
Committee on Membership.

*Expects to submit report at 1949 annual meeting.

*Committee on Library.
*Committee on Committees.
*Committee on Legislation.
*Committee on Reciprocal Relations with the Institution of Water Engineers.
***Committee on Classification of Water Works Employees and Salaries.
Committee on Survey of Ground Water Supplies in New England. This committee recently submitted a progress report, which was printed in the June, 1949, issue of the JOURNAL.
Committee on Rainfall and Yield of Drainage Areas. Tabulation of data since 1941 under way.
***Committee on Cathodic Protection of Steel Tanks and Standpipes.
Committee on Coëfficients for Friction in Pipe Lines.
Committee on Water Quality Tolerances for Industrial Uses.
**Committee to Report on Developments in our Knowledge of Corrosion and its Mitigation.
**Committee on Reinforced Concrete Pressure Pipe. (Joint Committee with A. W. W. A.)
**Committee on Code for Pressure Piping. (Joint Committee with A. S. M. E.)
**Committee on Laying Cast-Iron Pipe. (Joint Committee with A. W. W. A.)
**Committee on Specifications for Steel Pipe. (Joint Committee with A. W. W. A.)
***Committee on Steel Standpipes and Elevated Tanks. (Joint Committee with A. W. W. A.)
**Committee on Hydrant Specifications. (Joint Committee with A. W. W. A.)
Committee on Valve Box Frames and Covers.
**Committee on Gate Valves. (Joint Committee with A. W. W. A.)
Committee on Federal Activities. (Joint Committee with A. W. W. A.)

*Expects to submit report at 1949 annual meeting.
**Expects to submit progress report at 1949 annual meeting.
***Expects to submit report later in 1949.

*Committees Not Reporting*

The following committees are joint committees assigned to important subjects and they are presumably working toward the submission of reports, but no information has been received from the committee chairmen as to the status of the work or the continuance of the committees for some time. The Executive Committee may wish to check further on the status of the work of these committees.

Committee on Specifications for Cast-Iron Pipe and Fittings. (Sectional Committee under A. S. A.)

Committee on Standardization of Pipe Flanges and Fittings. (Sectional Committee under A. S. A.)

Committee on Sluice Gates. (Coöperating with A. W. W. A.)

*Discontinuance of Committees*

In the case of the following committees, the committee chairmen recommend discontinuance:

Committee to Investigate Grounding. (Coöperating with the American Research Committee on Grounding.)

Committee on Meter Specifications. (Joint Committee with A. W. W. A.) The committee chairman reports he expects that the 1949 committee report will wind up the committee activities.

In the case of the following committee, which was a Joint Committee with the A. W. W. A., the A. W. W. A. has discontinued its committee and the desirability of the continuance of the committee of our Association is questioned, unless it is set up as a new committee and some specific assignment is undertaken:

Committee on Distribution System Safety

*New Committees*

No new committees were appointed during the year. One suggestion was received by this committee to the effect that a committee might be appointed by the Association to follow up the stream-pollution abatement program as it affects water-supply interests. It would seem to this committee that the appointment of such a committee should carry with it some definite assignment. In this

connection, the proposed classification of streams in New England by the recently created New England Interstate Water Pollution Control Commission according to proposed highest use will be of interest to water-works men.

In reports last year and previously this committee has referred to the desirability of establishment of a program of public education in the water-supply field through paid expert service or in some other way. We still believe that this desirable objective should not be lost sight of.

*Conclusions and Recommendations*

It is recommended that the standing committees listed above be reappointed as indicated, that the activities of a few committees, listed separately, which have not reported, be further checked, and that consideration be given to discontinuance of three committees listed.

Respectfully submitted,

*(Signed)* WARREN J. SCOTT, *Chairman*
ROGER W. ESTY
HARRY U. FULLER
EARL R. PERRY
WILLIAM E. STANLEY

## REPORT OF COMMITTEE ON TECHNICAL PROGRAM

*To the New England Water Works Association:*

In the year 1949 your committee has arranged the program of technical papers for the meetings held during the year. These have included:—

a. The seven Boston luncheon meetings and the out-of-Boston meetings held at Quabbin Reservoir and Mystic, Conn.
b. The 68th Annual Convention at The Balsams.
c. The June conference at Newcastle, N. H.
d. The Chemists' Round Table and the Superintendents' Round Table, held in the morning of the monthly meetings in Boston.
e. The lecturer for the Water Works School.

This series of technical papers has involved the presentation of some thirty formal papers, in addition to the speakers for the Round Table discussions. The Superintendents' meetings have been arranged by William B. Duffy and the Chemists' Round Table by George G. Bogren of the committee. The programs for the Quabbin and Mystic meetings were arranged by the local committees in charge of arrangements, to whom the Program Committee is much indebted.

In comparing the number of formal papers given before the New England Water Works Association with the programs of other engineering societies, it is obvious that your committee is faced with a real burden in providing for the scheduled meetings. Furthermore, the existing civil engineering societies and the increasingly important State water-works associations furnish competition for papers.

As a practical matter, all this adds up to the fact that the committee does not have sufficient papers offered to meet the needs of the programs. Hence very definite efforts must be made by the committee to anticipate our needs by securing papers and even suggesting subjects which appear of interest to qualified authors.

In planning for another year, it is obvious that the same sit-

uation regarding papers will obtain. Without doubt a certain number of very excellent papers will be offered to the committee, but unquestionably the committee must continue to solicit papers. It is my hope that, with more construction during the last few years, we may have an increasing number of descriptions of new work, which are always the subjects of interesting papers.

In reporting last year, Stanley Dore mentioned the fact that many felt that more superintendents' papers should be included. The committee recognized this but found that many superintendents with interesting topics in mind did not feel qualified to present a formal paper to the afternoon sessions, preferring the informal discussions of the Superintendents' Round Table. I would recommend that the effort to obtain papers from the superintendents be continued. I hope that all the members of the Association will both review their own work with a view to writing a paper and also pass on to the committee ideas for interesting papers.

As chairman, I wish to take this opportunity to thank the members of the committee for their coöperation, without which this series of programs could not have been arranged. I also want to thank the Secretary and the Assistant Secretary of the Association for their help.

Respectfully submitted,

*(Signed)* TRUMAN H. SAFFORD, *Chairman*

## REPORT OF LIBRARY COMMITTEE

September 7, 1949

*To the New England Water Works Association:*

There is no special activity for the Committee to report, except that the chairman has visited the Library and discussed with Mrs. Melrose the utilization of the restricted space on the shelves. There appears to be a slight increase in the use of the Library by the membership.

Respectfully submitted,

*(Signed)* KARL R. KENNISON, *Chairman*
HARRY L. KINSEL

## ANNUAL REPORT OF THE COMMITTEE ON MEMBERSHIP—1949

August 31, 1949

*To the New England Water Works Association:*

The Membership Committee submits herewith the following report of changes of membership in the Association during the past fiscal year:

| | Regular | Junior | Associate | Corporate | Total |
|---|---|---|---|---|---|
| | | | *New Members* | | |
| | 52 | 2 | 6 | 1 | 61 |
| | | | *Loss of Members* | | |
| Resigned | 12 | | 5 | | 17 |
| Died | 11 | | | | 11 |
| Dropped | 9 | | | | 9 |
| | 32 | | 5 | | 37 |
| | | | *Net Gains* | | |
| | 20 | 2 | 1 | 1 | 24 |

Total membership as of August 31, 1949—922.
Total membership as of Sept. 16, 1949—932.

Respectfully submitted,

*(Signed)* JOHN B. KENNEDY, *Chairman*

JOSEPH C. MOORE
THEODORE CATE
WALTER J. SHEA
ELMER W. CAMPBELL
HAROLD W. GRISWOLD

## PROGRESS REPORT OF COMMITTEE ON REINFORCED CONCRETE PRESSURE PIPE

*To the New England Water Works Association:*

During the past year, your committee has acted jointly with Water Works Practice Committee 7-B of the American Water Works Association.

As part of the June, 1948, JOURNAL of the New England Water Works Association, "Tentative Standard Specifications for Reinforced Concrete Water Pipe—Steel Cylinder Type, not Prestressed", numbered 7B.1-T-1947, were included, your committee having a part in criticism, suggestion and approval during preparation.

During the year work has progressed by this Committee 7-B on preparation of a draft of Tentative Specifications for Concrete Pipe—Steel Cylinder Type, Prestressed, your committee again taking part in criticism, suggestion and approval. These will be submitted to the American Water Works Association for formal approval soon, after which we recommend they be printed in a supplement of our journal.

There is considerable agitation among some members of the committee for standard specifications for reinforced concrete water pipe without a steel cylinder, both prestressed and non-prestressed type. Your committee has joined in discussions as to the advisability of the preparation of such standard specifications by the Water Works Practice Committee 7-B of the American Water Works Association, including your joint members.

Respectfully submitted,

*(Signed)* STANLEY M. DORE
GEORGE A. SAMPSON

## PROGRESS REPORT OF COMMITTEE ON SPECIFICATIONS FOR STEEL PIPE

*To the New England Water Works Association:*

With the September, 1948, Journal of the New England Water Works Association were furnished "Standard Specifications for Electric Fusion Welded Steel Water Pipe of Sizes 30 Inches and Over", numbered 7A.3-1940, and "Tentative Revision of Standard Specifications for Steel Water Pipe of Sizes up to but Not Including 30 Inches", numbered 7A.4-1941-TR.

Frank A. Barbour represented this Association and aided the Water Works Practice Subcommittee 7A of the American Water Works Association in preparation of these. Your committee now acts jointly with this Subcommittee 7A, representing the New England Water Works Association in consideration of any changes of standard specifications for recommendation as standard specifications, which come before Subcommittee 7A.

Such specifications are subject to constant suggestions for improvement and some of these suggestions have been before your committee from time to time.

Respectfully submitted,

(*Signed*) STANLEY M. DORE
SCOTT KEITH

## REPORT OF COMMITTEE ON GATE VALVE SPECIFICATIONS

September 12, 1949

*To the New England Water Works Association:*

Your Committee on Gate Valve Specifications submits the following progress report.

The specification material assembled by the A.W.W.A. Committee under the chairmanship of F. M. Randlett has been turned over to Secretary Jordan's office, where it is expected that another draft of the revised specifications will be prepared and ready for distribution to committee members before the end of the year.

Your Committee has marked time during the year, except for the expression of an opinion adverse to the use of ounce metal for manganese bronze in the stem nut, as proposed by one of the valve manufacturers. At the same time, it re-affirmed its belief that the present provision of the specification, that stems of valves 30-inch and larger be made of stronger metal than those for valves 24-inch and smaller, should be retained.

Since it seems likely that the A.W.W.A. will take further action on the revision of this specification during the next few months, it is suggested that your Committee on Gate Valve Specifications be continued for another year.

Respectfully submitted,

(*Signed*) HAROLD W. GRISWOLD, *Chairman*
LELAND G. CARLTON
WALTON H. SEARS

# COMMITTEE TO REPORT ON DEVELOPMENTS IN OUR KNOWLEDGE OF CORROSION AND ITS MITIGATION

## First Report

*To the Members of the New England Water Works Association:*

The Committee to Report on Developments in Our Knowledge of Corrosion and Its Mitigation was established by the Association in 1942. The pressure of war activities on the membership of the Committee prevented any effective work during the subsequent years until July of 1948, when a meeting was held to determine its future course.

In the discussion of the future work of the Committee it became painfully obvious that a point of departure for this work had never been established. Where, for example, should the Committee begin its examination of developments in the knowledge of corrosion? Should the work of the Committee be directed toward informing the entire membership as to present knowledge of corrosion, or should it deal only with the very newest advances and therefore be useful only to the select few who already possess a considerable knowledge of the subject?

Further discussion led to the conclusion that the Committee might partially fulfill both objectives by adopting the following courses of action:

1. To prepare a basic report which would, in so far as possible, summarize present knowledge on corrosion.

2. Using this basic report as a point of departure, to examine critically the new developments in the field at such times as the Committee considers that sufficient evidence is at hand for examination and reporting.

The present report is submitted as the basic report of the Committee.

## I. Definition of Corrosion

### A. *Manifestation*

In order to carry on adequate studies of corrosion in the field of water supply, it is necessary that criteria be established that may be

used to determine the existence and the extent of the problem. Since corrosion has to do with piping systems and water supplies, its existence is recognized by its effects on either or both. In general, the effects of corrosion on the water supply are manifested much sooner than the effects on the piping system. This report will deal primarily with the corrosion of the interior surfaces of piping and will not be concerned, except indirectly, with corrosion of the exterior surfaces due to contact with various types of soils or to other agencies.

1. *Effect on System—Destruction, Tuberculation, Clogging*

Corrosion consists primarily of the solution of metal components of the piping system by the action of the various substances present in water. The continuous solvent action results in a weakening of the pipe structure, which eventually may manifest itself in many ways, such as:—

a. Leaks in service lines, mains, domestic piping;
b. Leaks in domestic hot-water boilers;
c. Corrosion of water-meter parts.

Inspection of any piping that has developed a leak will reveal the solvent effect of corrosive action in the form of pitting, dezincification, or general reduction in pipe thickness.

Another evidence of corrosion is the occurrence of tuberculation in the piping. When certain metals, especially iron, go into solution in water, they tend to react with the basic substances and the dissolved oxygen in the water and form insoluble compounds. These compounds tend to form and adhere to the pipe in the immediate vicinity of the point where the corrosion is taking place. This precipitate adheres to the pipe and accumulates in the form of tubercles. The effect of such tuberculation is to reduce the carrying capacity by a decrease in the effective diameter of the pipe and by an increase in the frictional resistance to flow. Where tuberculation is excessive, marked reduction of flow and pressure will occur, and reduction in flow and pressure in sections of a water-supply system may be taken as evidence of marked corrosion of the piping system.

2. *Effect on Water*

When corrosion of piping occurs, the metal goes into solution in the water in the form of charged atoms, which are called ions, and therefore the presence of these corrosion products in the water is evidence of the existence of corrosion.

a. *Soluble and Insoluble Metallic Compounds*

The presence of some metal ions in water may be evidenced by visible effects, such as the presence of sediment, by an increase in the turbidity of the water, by a change in the color, or by the imparting of a visible coloration to an otherwise satisfactory, colorless water.

b. *Turbidity, Color*

Where iron pipe undergoes corrosion, iron hydroxide is formed, which is usually manifested in the familiar form of brown iron rust, somewhat fluffy in appearance. Occasionally, during a heavy draft on the pipe or a change in the direction of flow, a certain amount of tuberculation of iron hydroxide will be loosened from the main and appear in the tap water as a brownish sediment. Small quantities of iron in solution in a water will impart a turbidity or a yellowish color to the water, because of the presence of iron in colloidal form. The presence of high concentrations of copper in solution will impart a bluish cast to the water. Such concentrations are rather unusual in water supplies, but the addition of soap to the water or the presence of a large volume of water, as in a bathtub, will tend to bring out the bluish color. The presence of zinc or lead rarely imparts either color or turbidity to a water.

c. *Taste*

High concentrations of metallic ions will impart a characteristic, unpleasant metallic taste to the water. For instance, iron in solution imparts a sharp metallic taste in concentrations of approximately 0.5 to 2.0 ppm; copper is similarly perceptible in concentrations of about 5 to 10 ppm, and zinc in concentrations of about 20 pm.

d. *Toxicity*

The presence of metallic ions in water may sometimes affect the health of the consumer. Of the various metals commonly found in

water supplies, lead is the most harmful. Concentrations in excess of 0.1 ppm are considered unsafe for potable supplies. Although there is little or no evidence of damage to health from the presence of either copper or zinc in concentrations such as occur in water supplies, it has been found desirable to limit the concentration of copper to a maximum of 3.0 ppm and of zinc to 15 ppm in potable waters. There is no evidence of any physiological effect produced by excessive amounts of iron in solution, but its presence is objectionable for various domestic purposes in concentrations of over 0.3 ppm.

B. *Quantitative Estimation of Corrosion*

1. *Methods Available for Measuring Corrosion*

Measurement of the extent of corrosion consists in determining either the extent of its action on the metallic piping, its effects on the water stored in the pipes, or both.

Quantitative measurement of the extent of corrosion of the piping system may be based on any of the following methods:

a. Loss of weight of the metal;
b. Depth of pitting of the metal in a given time interval;
c. Change in the friction coëfficient of the pipe;
d. Frequency of required meter overhaul and of incidence of failure of domestic plumbing fixtures, such as hot-water boilers.

The first two methods are of value in the determination of the relative corrodibility of various metals and as a guide in the choice of the best method for a given purpose. The extent of the penetration of a metal due to corrosive action in a given interval of time may be used in gauging the probable useful life of the metal, and comparison of these effects on two or more metals under the same conditions of corrosion may be used to estimate the relative merit of such metals. These methods are of relatively little use in the water-works field, first, because most corrosion problems are concerned with old piping systems and, secondly, because where the choice of new piping is involved, the time required to carry out such measurements is usually not available. Once a piping system is installed there is rarely an opportunity to remove sections for study of corrosion effects.

In this connection it may be stated that the so-called "jar test" —in which a small section of pipe is allowed to stand in contact with a fixed quantity of water for a certain interval of time and the results are observed, usually visually—is not a satisfactory method of predicting the results that will be obtained in actual use. The rapid change in the corrosive properties of the water and the unusual initial corrosion effects on the metal make the jar test of little value.

The tuberculation caused by corrosive action offers a satisfactory means for the quantitative determination of the extent of corrosive action. The effect of tuberculation is, of course, to increase the friction loss through the pipe and to reduce the effective diameter of the piping. Where it is known that the tuberculation is caused primarily by corrosion, measurements for the determination of the value of "C" in the Williams and Hazen formula offer a fair criterion of the condition in the mains. However, it must be noted that some forms of pipe incrustation are not related to corrosion.

Where means for such measurements are not available, a more qualitative and less satisfactory method is to look for corrosion and clogging of the meter parts and to note the interval between the required cleanings of meters. Too frequent clogging of meter gears indicates excessive corrosion. Similarly, unusually short life of domestic plumbing systems, such as hot-water boilers and house piping, offers a rough indication of the extent of the corrosive effects of the water.

The change in the quality of the water between the source and the consumer's tap after passage through the various service lines offers an indirect measure of the extent of corrosion of the various kinds of metallic piping in the system. An increase in the content of iron, copper, zinc or lead indicates corrosive action and its intensity can be estimated by considering the increase in metal concentration with respect to the time of contact between water and pipe.

The dissolved-oxygen content of the water can be used as a measure of the extent of corrosion of iron piping. Since oxygen is a primary agent in promoting corrosion and since it is used up in proportion to the amount of iron being dissolved, the drop in the dissolved-oxygen content between any two points in a piping system is a measure of the extent of the corrosive action taking place there.

A far less satisfactory indication, yet one which may be of some value, is the extent of the manifestation of some of the effects of corrosion on various plumbing fixtures. For instance, numerous complaints of green stains on white porcelain fixtures are an indication of corrosion of copper or brass pipe. The presence of excessive iron in solution results in numerous complaints of brown stains on plumbing fixtures and the staining of clothes in the process of laundering.

2. *Evaluation of Anti-Corrosion Treatments*

Where steps are taken to reduce the corrosiveness of the water by chemical treatment or otherwise, it is essential that adequate data be obtained to determine the effectiveness of such treatment. As previously indicated, the effects of corrosion are manifested in various ways and after various time intervals. Whether treatment has resulted in a decrease in the corrosion, pitting or tuberculation in the mains and service lines can be determined only after a period of several months or years. It must be borne in mind that when treatment is begun, the piping system consists of mains and service lines of various metals in varied condition with respect to corrosion. Some may already be badly pitted or tuberculated; some may be relatively free from pits or tubercles; all have coatings of corrosion products, pipe growths or organic matter of different densities and protective value. Therefore, when the water applied to such a system is treated to alter its corrosive properties, the manifestation of this change in corrosiveness will be varied and difficult to evaluate immediately. The longer the interval of treatment, the clearer will be the picture of the relative effectiveness of the treatment. Where the treatment has been accompanied by a program of main cleaning or flushing, some of the immediately apparent effects may be due merely to such cleaning. Any other steps taken in conjunction with the corrosive-correction treatment, such as elimination of dead ends, should also be properly evaluated in the over-all picture.

In general, the change in the corrosive effects of a water on a piping system can be evaluated only after a period of possibly six months or a year, when a reduction in the frequency of the occurrence of leaks in service lines, clogging and corrosion of the meter parts, clogging of piping, or loss of water pressure at taps indicates the effectiveness of the corrosive-correction treatment.

The effectiveness of the treatment first manifests itself in improvement in the condition of the water as drawn from taps throughout the system. For this purpose it is desirable that, as an aid in the determination of the improved water quality, certain representative taps be chosen with respect to the type and condition of the water-supply lines of the system and samples of the water be drawn from them under standard conditions of flow for a period of time before treatment is begun. After treatment has been instituted, additional samples can be taken under the same conditions and the change, if any, in the quality of the water can be noted. Such a sampling program should be well planned as to representative samples and be carried out for a sufficient period of time before and after treatment to give a proper picture of the condition of the water. Tests for the various metal ions as well as the dissolved-oxygen content will be especially valuable in this work.

3. *Relation of Measurements to Consumer Complaints*

As previously indicated, corrosive action is continuously occurring when metal piping is in contact with water. The extent of the action varies with the type of piping and the character of the water supply. The point at which a water is considered sufficiently corrosive to require corrective treatment is quite dependent on the particular community concerned. The water-works superintendent is concerned especially with corrosion of piping as a cause of leaks or breaks that require repairs, the clogging or corrosion of meter parts, and the tuberculation or clogging of mains and service lines. The consumer, on the other hand, is especially aware of corrosion as it affects the quality of the water. Thus the staining of clothes or of plumbing fixtures by iron or copper compounds is apt to cause complaints to the water department. The appearance of sediment, such as iron rust due to sloughing off of deposits in pipes, will cause considerable objection. There is usually no close relationship between the extent of the corrosive effects, the number of complaints, and the consequent public pressure to require corrective treatment of the water supply. Because of the variation in public reaction to the effects of corrosion, caution must be exercised to avoid evaluating the effects of corrosive treatment solely on the basis of consumer reaction. While

the incentive for initiation of corrective treatment in many cases comes from the reaction of the consumers, consumer opinion is not too reliable an index of the effectiveness of the anti-corrosion treatment. Reduction in the number of complaints about the appearance of the water and the staining of clothes and fixtures is of value in judging the effectiveness of treatment, but the chief reliance should be placed on the analytical data concerning the water at the various taps before and after treatment. In any case, a sufficient time interval should be allowed before deciding on the effectiveness of treatment, because, as has already been indicated, corrosion is a very slow process and many of its effects are not manifested until an interval of months or years has passed.

## II. Fundamental Reactions of Corrosion

No metal is truly stable in the presence of moisture and oxygen, and all metals tend toward ultimate conversion to oxides, hydroxides or salts of the metallic element, with consequent destruction of the integrity of the metal. There are some metals for which this conversion is so slow that it may be regarded as substantially nonexistent; unfortunately all of these are sufficiently rare and expensive to be unavailable for general water-works use. Those metals that are normally within the economic reach of the water-works engineer are all subject to corrosion, and the differences among them are small compared with the differences between them and the so-called noble metals.

The most widely accepted theory of the mechanism of corrosion may be called the electro-chemical theory; this theory is supported by an imposing array of observation and experiment. It represents the corrosion reaction as proceeding in a series of four well-defined steps:

*Step I—Anodic Reaction.* This is the release of metal ions, each carrying one or more positive charges, to the water, together with the liberation of an appropriate number of electrons, each carrying a single negative charge, to the main mass of the metal. It takes place entirely on the surface of the metal. It is represented below for some of the common metals, the term $e$ signifying an electron:

| | | |
|---|---|---|
| Iron: | Fe(metal) | $\longrightarrow Fe^{++} + 2e$ |
| Zinc: | Zn " | $\longrightarrow Zn^{++} + 2e$ |
| Lead: | Pb | $\longrightarrow Pb^{++} + 2e$ |
| Copper: | Cu | $\longrightarrow Cu^{++} + 2e$ |
| Aluminum: | Al | $\longrightarrow Al^{+++} + 3e$ |

*Step* II—*Cathodic Reaction.* The accumulation of electrons in the metal would soon stop the action of positive ions by sheer electrostatic attraction. However, in the presence of water the surplus electrons can be eliminated by reaction with hydrogen ions from the water. Since the electrons can move freely through the metal, the site of this reaction is not necessarily limited to the same area as that of the anodic reaction and, indeed, often takes place at some distance from it. The reaction is the same for all metals:

$$2H^{+} + 2e \longrightarrow H_2 \text{ (gas)}$$

When corrosion takes place in a strongly acid solution, the bubbles of hydrogen gas can be seen to form and break away from the surface of the metal. In all other circumstances the hydrogen is removed by another mechanism and may possibly never exist as a gas in the true sense.

*Step* III—*Depolarization.* Accumulation of the hydrogen film on the metal again would break the corrosion chain, if it were not rapidly eliminated. In the presence of dissolved oxygen this elimininnation takes place by the reaction of hydrogen and oxygen to form water. The reaction is the same for all metals:

$$2H_2 + O_2 \longrightarrow 2H_2O$$

*Step* IV—*Reactions of the Metal Ions.* Most of the metal ions released to the water undergo various reactions with ions present in the water. Many of these reactions result in insoluble products that coat the metal and protect it against further corrosion; often the apparent resistance of the metal to corrosion is due to the formation of such coatings. On the other hand, some of these insoluble products crystallize in such a highly pervious form that they are of limited value as a protection; iron rust is a good example. The real objective of much of the anti-corrosion treatment of water is to form impervious coatings of one kind or another on the metal by reaction with the substances introduced into the water. A few of the possible re-

actions of the various metals in natural or treated waters are given here:

Iron: $2Fe^{++} + \frac{1}{2} O_2 + 4OH^- \longrightarrow 2H_2O + Fe_2O_3$ (rust)
or $2Fe^{++} + \frac{1}{2} O_2 + 4HCO_3^- \longrightarrow 2H_2O + 4CO_2 + Fe_2O_3$
Zinc: $5Zn^{++} + 6OH^- + 2CO_3^{--} \longrightarrow 2ZnCO_3 \cdot 3Zn(OH)_2$ (basic zinc carbonate)
Lead: $Pb^{++} + CO_3^{--} \longrightarrow PbCO_3$ (lead carbonate)
or $3Pb^{++} + 2CO_3^{--} + 2OH^- \longrightarrow 2PbCO_3 \cdot Pb(OH)_2$ (basic lead carbonate)
Copper: $2Cu^{++} + CO_3^{--} + 2OH^- \longrightarrow CuCO_3 \cdot Cu(OH)_2$ (basic copper carbonate)
Aluminum: $2Al^{+++} + 6OH^- \longrightarrow 3H_2O + Al_2O_3$ (aluminum oxide)

In the presence of other appropriate ions in the water, such as phosphate or silicate ions, insoluble compounds of the metals with these ions will be formed. None of these reactions will occur unless the necessary ions are present in the water in sufficient quantities.

* * *

Corrosion is thus seen to be a complex reaction composed of several steps. Interference with any part of the sequence will alter the course or rate of the entire reaction. This explains why corrosion is affected by a large number of factors and why statements regarding it are frequently conflicting or confusing. The conflicts come from disregarding factors which are not obvious but which affect materially some part of the sequence of reactions.

*Factors That Influence the Steps in the Corrosion Sequence*

*Step* I—*Anodic Reaction.* The tendency for a metal to release ions to water is a fundamental property of the metal itself. This tendency can be measured; it is called the oxidation potential of the metal. The noble metals are characterized by low values of the potential, the easily corroded metals by high values. Arranging some of the more common metals in order of decreasing tendency to release ions produces the following result:

| | |
|---|---|
| Aluminum | Tin |
| Zinc | Lead |
| Chromium | Copper |
| Iron | Silver |
| Nickel | Gold |

If no steps other than the release of ions were involved in corrosion, this series would represent the comparative susceptibility of these metals to corrosion. However, other factors complicate the picture. Aluminum, zinc and chromium all appear ahead of iron in this series and on this basis alone would be expected to be more susceptible to corrosion than iron, but all three of these metals are much more corrosion-resistant than indicated by their position, because in step IV of the sequence they form impermeable films of oxide or other compounds, whereas iron does not. Under circumstances which prevent the formation of these films, the three metals take their proper place in the series. Such conditions are, however, not likely to occur in practice; hence these metals enjoy a high reputation for resistance to corrosion. Alloying of a metal with another will also alter its relative position in the series.

*Step* II—*Cathodic Reaction.* The ease with which hydrogen can be deposited on various metal and other surfaces is subject to considerable variation. It is, for example, more difficult to deposit hydrogen on zinc or tin than on iron, and easier to deposit it on certain oxides of iron than on the metal itself. This accounts in part for the protective action exercised by galvanizing or tinning, and for the localized corrosion or pitting produced by a piece of mill scale on an iron surface. In the latter case the mill scale becomes a cathodic area, at which hydrogen is discharged, and the anodic reaction is concentrated in areas near the piece of scale, with the result that there is a strongly localized attack. Similarly, if two different metals are placed in contact with each other, the one lower in the series shown previously will become the cathodic area and the attack will be concentrated on the one higher in the series.

The rate of discharge of hydrogen is also influenced by the hydrogen-ion concentration (or the pH value) of the water in contact with the metal. Three ranges of hydrogen-ion concentration can be distinguished:

1. The acid range, corresponding to pH values of about 4.5 or lower. In this range the rate of corrosion is directly related to the hydrogen-ion concentration and the hydrogen is evolved directly as gas.

2. The intermediate range, from a pH value of about 4.5 to one of about 10.0. In this range the importance of the hydrogen-ion concentration is small compared to that of other factors and the corrosion rate varies little, if at all, with pH value. Sometimes this fact is obscured by the influence of the pH value on the formation of protective films of certain types, notably carbonate and silicate films.

3. The alkaline range, corresponding to pH values of 10.0 or greater. In this zone the formation of hydroxide, carbonate or other films is a direct function of the pH value, and corrosion accordingly again depends greatly on the pH value.

*Step* III—*Depolarization*. In waters possessing pH values between 4.5 and 10.0 the depolarization of hydrogen by dissolved oxygen is of great importance to the corrosion sequence. The oxygen concentration and the velocity of flow, which determines how fast fresh oxygen is brought to the metal, both exert a great influence on the rate of corrosion. Complete removal of dissolved oxygen from water will substantially eliminate its power to attack metals in this zone of pH values. Unfortunately, complete removal of dissolved oxygen is seldom feasible in water-works practice.

If the concentration of oxygen varies at points along the surface of the metal, the areas where the concentration is high become cathodic areas and those where it is low, anodic areas. The attack is concentrated at the anodic areas and pitting is produced.

*Step* IV—*Reactions of the Metal Ions*. Corrosion can be stopped very effectively, if a layer of impervious non-metallic material is interposed between the metal surface and the water. Obviously such a material—for example, asphalt or cement—may be deliberately applied to the metal; the effectiveness of such a coating will depend on the imperviousness of the material and the care with which it is applied.

Many of the metals, under suitable conditions, will react with components present in the water to form impervious films that protect the metal from further attack. A complete catalogue of such films would be a major undertaking, but a few of the more common ones may be mentioned here. Films made up of oxides or hydroxides

of the metal are numerous; aluminum, chromium, zinc and iron are familiar examples. Carbonates or basic carbonates of the metal are also common, such as, for example, those formed by zinc and copper. Under special conditions, films of metal silicates and phosphates or of metals combined with organic radicals may be encountered.

In other cases the protecting film may be formed entirely from substances present in the water, without much involvement of the metal ions; examples are the films of calcium carbonate or silicate produced by certain types of anti-corrosion treatment of the water and the protection afforded by some types of organic compounds.

These protecting films vary tremendously in thickness; furthermore, some are effective barriers against corrosion when only one molecule thick, whereas others are relatively ineffective even when present as a heavy deposit. The composition of the water and numerous other factors affect the stability, composition and physical structure of the films. In short, it is this latter step in the corrosion process that exhibits the greatest complexity and accounts for most of the observed variability in the total rate of attack on metals.

## III. Methods of Mitigation of Corrosion

### A. *Self-Corrosion*

Self-corrosion is that resulting from the inherent tendency of all metals to dissolve in water, aqueous solutions of water-soluble materials, or mixtures of water with some other substance which is neither soluble in nor a solvent for water. It is known as electrochemical corrosion and is the type of corrosion commonly found in piping systems. This discussion applies primarily to water systems. Self-corrosion may be mitigated by

(1) Selection of materials;
(2) The use of protective coatings;
(3) Treatment of the water.

These topics are treated below.

1. *Selection of Materials.* Pipe may be non-metallic and there are many varieties of such pipe available. For the water-works industry, however, only asbestos-cement pipe, concrete pipe (and masonry conduits) and wooden pipe are at present suitable and

practicable. Of these, wooden pipe is now used only as wood-stave pipe and its use in this section of the country is practically non-existent, except in some water-power developments.

Asbestos-cement pipe withstands salt water and soft and corrosive waters, but not acids. It is available for mains only and for such use is an important competitor of metallic pipe. It has been found to increase the alkalinity and hardness of water when first installed, an effect which gradually diminishes but may persist for six months or more. The N. E. W. W. A. JOURNAL, Vol. 51, No. 3 (September, 1937), contains a series of papers on the manufacture, laying and use of asbestos-cement pipe.

Concrete pipe is increasingly used for large mains. The present outstanding example of the use of pipe of this type is the Hultman Aqueduct of the Boston Metropolitan Supply, described in detail in the N. E. W. W. A. JOURNAL for September, 1941, page 315.

For service connections and interior and other small piping, there are available pipes of various corrosion-resistant metals, such as copper, brass, lead, tin, monel, stainless steel, silicon bronze, nickel-molybdenum-chromium-iron alloys and others.

Copper is highly resistant to corrosion but, for very soft waters containing large amounts of carbon dioxide, tin-lined copper is to be preferred.

Brass pipe containing 85% or more of copper (red brass) is highly resistant to corrosion. Brass pipe containing 60% or less of copper will dezincify in soft waters; 67% copper (alpha) brass is fairly resistant. Green stains and precipitates may appear when copper or brass pipe is used with very soft waters containing large amounts of carbon dioxide.

Lead pipe should never be used with soft waters, because of the toxicity of lead salts. It is suitable for hard waters.

The other corrosion-resistant materials noted above are, in general, too expensive for use as water pipes and are used mostly in special work, though silicon bronze is used extensively in sewage plants, especially for valves, sluice gates and stop shutters.

2. *Protective Coatings.* "When pipe material is subjected to corrosive conditions to which it is susceptible, some form of protective coating may be more economical than resorting to a more re-

sistant but more expensive material. Since corrosion may arise from the fluid conveyed by the pipe, from the atmosphere, or from the soil environment in the case of a buried pipe, protection may be needed either internally or externally, or both, depending on circumstances. In the case of internal attack, it may be possible to reduce the corrosive nature of the fluid conveyed."*

Protective coatings and linings for ferrous pipes, valves and fittings may be (a) non-metallic or (b) metallic.

a. *The non-metallic coatings* most commonly used are paints, asphaltic or bituminous materials, and cement. For special purposes, such as the handling of liquid chlorine and chlorine compounds, rubber-lined pipe is also available.

(i) *Paints,* while effective against atmospheric corrosion, are less so against under-water and underground corrosion. Therefore they are seldom used for underground pipes, but rather for ferrous valves and for submerged steel structures where galvanizing is not practicable or the expense of galvanizing is not warranted. Paints commonly used in water-works equipment, especially that subjected to submergence or damp atmosphere, have asphaltic or bituminous bases, often applied over a base coat of red lead.

(ii) *Asphaltic or bituminous linings and coatings* are made from natural asphalt or coal-tar pitch. They are applied hot by dipping or by spinning. The A. W. W. A. standard specifications for cast-iron water pipe and fittings cover in detail the approved practices of coating cast-iron pipe with hot, coal-tar pitch varnish by dipping. In water-works practice no other coating is normally applied to cast-iron pipe.

Steel pipe with its greater susceptibility to corrosion and its lesser thickness as compared with cast-iron pipe requires, in general, more attention to coating, especially the external coating of submerged or buried pipes. For steel water mains the A.W.W.A. has formulated specifications for coal-tar enamel coatings (AWWA 7A.5 and 7A.6).

The corrosion protection provided under these specifications is as follows:

For the inside of all steel pipe, a coat of coal-tar primer fol-

*"Piping Handbook" by Sabin Crooker.

lowed by a hot coat of coal-tar enamel, applied either by manual or by mechanical means.

For the outside of pipe, 30 in. and over to be placed underground, a coat of coal-tar primer followed by a hot coat of coal-tar enamel and one coat of water-resistant whitewash.

For the outside of steel pipe smaller than 30 in. to be placed underground, a coat of coal-tar primer followed by a hot coat of coal-tar enamel, into which is bonded an asbestos felt wrapper, with a finish coat of kraft paper or one coat of water-resistant whitewash.

For the outside of all steel pipe to be placed above ground exposed to the weather, two coats of synthetic red-lead primer (or one coat of synthetic red-lead primer and one coat of synthetic white enamel) and one coat of aluminum paint.

(iii) *Cement linings or coatings.* Cement-lined ferrous pipe and fittings, both cast-iron and steel, are used extensively in New England. The A.W.W.A. has prepared specifications (AWWA 7A.7) for "Cement-mortar Protective Coating for Steel Water Pipe 30 Inches and Over" and a similar specification for cast-iron pipe. Cement-lined pipe, both steel and cast-iron, conforming thereto are commercially available. Mains may also be lined in place by patented processes. Cement linings have the same temporary effect on quality of water when first installed as has asbestos-cement pipe. A cement lining is not wholly impervious to water, but water that penetrates forms an alkaline solution in contact with the iron and tends to inhibit corrosion. Water of low pH value, however, continually reacts with the coating, so that cement-lined pipe is not suitable for highly acid waters.

b. *Metal coatings of ferrous pipe.* Of the various metallic coatings and linings available, the most commonly used in water works are zinc and lead.

Hot-dip galvanizing is the simplest and commonest method of applying zinc to steel pipe, and the use of pipe galvanized by this method is widespread in interior piping, in service connections and, to a limited extent, in small mains. Galvanizing provides reasonably good protection against atmospheric corrosion, but it is a poor type of protection with some waters. Zinc is protective because it is anodic with respect to iron and it is intended to be consumed by corrosion.

Too long life should not be expected of it. ASTM specification A 120-44 covers hot-dipped, zinc-coated steel pipe.

Lead-lined pipe and fittings are suitable for sea water and weak acids but should never be used with soft domestic waters because of toxicity. Since lead is cathodic with respect to iron, a lead lining must be continuous, eliminating any access of the liquid to the iron. This necessitates the use of flanged joints with the lead lining turned back over the face of the flange.

Other metallic linings and coatings are available, but in general they are used mainly for protection against atmospheric corrosion and their value for water pipe and fittings is doubtful. They may be listed briefly here. *Aluminum* may be applied by "calorizing," a process similar to Sherardizing. *Copper, nickel, chromium* and *cadmium* may be applied by electroplating. There are also processes or treatments which alter the surface of the iron (such as Parkerizing, Bonderizing, anodizing, etc.) and produce moderately corrosion-resistant films of iron oxides or phosphates on the surface.

c. *Natural protective coatings.* Under certain conditions mineral coatings, coatings formed by corrosion products, and those formed by organic slime appear to act as corrosion inhibitors. Deposits of mineral coatings of calcium carbonate or of silicates, due to the presence of those substances in the water, may occur to retard corrosion and this phenomenon explains the lower corrosiveness of hard waters. Oxides, hydroxides, carbonates, basic carbonates, silicates, etc., of the metals, formed by reaction of dissolved metals with substances in the water, may form coatings which cause a decrease in the rate of corrosion and may ultimately stop it almost completely. Organic slimes also retard corrosion, a fact accounting partly for the observation that filtered waters are often more corrosive than unfiltered.

3. *Mitigation of Corrosion by Treatment of Water.* There are numerous methods of altering the composition of water so that its corrosive attack on metals is diminished; on analysis, most of these can be classified under one or more of the following groups:

a. *Treatments that reduce the hydrogen-ion concentration of the water.* This covers the use of the ordinary alkaline agents, such as soda ash and caustic soda.

b. *Treatments that induce deposition of mineral films on the metal.* This includes treatments to produce calcium-carbonate saturation, treatments with silicates and probably also the treatments with complex phosphates.

c. *Treatments with organic corrosion inhibitors.* These substances deposit organic protective films on the metal; they include an enormous range of compounds, from glue to complex amines.

d. *Treatment with passivating agents.* These are strong oxidizing agents that convert the metal surface to an impervious oxide film.

e. *Treatments to remove dissolved gases, principally dissolved oxygen, secondarily carbon dioxide.*

Items c and d are not applicable as yet to the treatment of drinking water, since the substances used are toxic or otherwise objectionable and yet must be used in moderately large quantity to be effective. Item e is rarely employed in water-works practice because of technical difficulties, although removal of carbon dioxide by aeration is sometimes practiced as an anti-corrosion measure. In this case its value is dubious, since the oxygen added may be much worse than the carbon dioxide removed. Carbon dioxide is also destroyed in process a. This leaves us with items a and b as our main reliances in corrective treatment of water.

*Applications of Methods.* In practice it is often difficult to separate and evaluate methods a and b, since in many waters treatment with alkaline reagents of any sort will produce supersaturation of the water with calcium carbonate, calcium silicate, or a number of other similar compounds capable of acting as protective films. However, in many of the soft waters of New England the separation is very well defined, since the content of calcium is such that no reasonable amount of treatment with the sodium alkalies will produce supersaturation with calcium salts. In this case the two types of treatment can be discussed separately.

a. *Treatment to reduce the hydrogen-ion concentration, or to raise the pH value.* This type of treatment has as its objective the slowing of step II in the corrosion chain by making hydrogen ions less available. As previously noted in the theoretical discussion, this procedure is relatively ineffective in the pH zone from 4.5 to 10.0, which covers most natural and treated waters.

The chemicals used in practice are principally soda ash and caustic soda, which are added in amounts sufficient to produce a desired pH value. The statement above regarding the pH zones in which such treatment is effective has been confirmed by the experience of many New England water-works operators, who have had little success with this type of treatment. It is much more successful in harder waters, but here it succeeds through the combination of the alkaline agents with the calcium of the water to produce protective films.

b. *Treatment to produce deposition of mineral films*

(i) *Calcium-carbonate films.* Water treated so as to produce a condition of saturation or near-saturation with calcium carbonate shows a great decrease in its ability to attack metals, although the attack is not entirely eliminated. The reduction is due to the tendency of the water to deposit, on the metal, films composed in part of calcium carbonate and in part of carbonates of the metal itself. The type of treatment required to produce a condition of saturation varies with the composition of the water. Hard waters may require only the addition of soda ash; soft waters with moderate amounts of alkalinity will require only lime, but soft waters of very low alkalinity may need both.

The quantitative relationships involved in such treatments were developed originally by Langelier (Jour. Amer. Water Works Assn., *25,* 1500, 1936) and extended by him and others (Moore, Jour. New England Water Works Assn., *52,* 311, 1938; Hoover, Jour. Amer. Water Works Assn., *30,* 1802, 1938; Langelier, *ibid.*, *38,* 169, 1946) to allow calculation, from the analysis of the water, of the chemicals needed for treatment. Previous to Langelier's work, Baylis had shown how the treatment required could be determined by testing treated samples against calcium carbonates; this is the so-called "marble test."

While the protection against corrosion afforded by treatment of water to calcium-carbonate saturation is not absolute, it is still the most widely used method of controlling corrosion by water treatment. The chemicals used are relatively inexpensive and are already familiar to the water-works operator through their other applications in water-works practice. There are few problems involved in dosing, and under- or over-dosing for short periods has little noticeable effect.

(ii) *Silicate films.* The addition of soluble silicates (principally sodium silicate) to water in sufficient quantities will produce incipient precipitation of calcium silicate or of silicates of the metals in contact with the water. The metals will tend to become coated with silicate films, which appear to provide good protection. Not so much is known of the quantitative relationships involved in silicate-film formation as in the formation of carbonate films. However, there are numerous instances of successful treatment with silicates in which dosage has been determined by experience. Dosing involves no great problems; the silicates are physiologically harmless and the quantities required are small.

(iii) *Polyphosphate films.* The complex, glass-like sodium phosphates—so-called meta- and pyro-phosphates—are a comparatively new discovery in anti-corrosion treatment. When added to water in relatively small quantities, under proper conditions, there is no doubt that they will materially reduce the rate of attack on ferrous metals. The presence on the metal of a film, only a few molecules thick, of phosphate-containing material is demonstrated by the appearance of "interference colors." At present this film is believed to consist of compounds of the polyphosphates with the metal or with calcium from the water. The polyphosphates are relatively expensive per pound, but the smallness of the dose required allows them to compete favorably with the anti-corrosion treatments mentioned previously. The treatment is simple in application, involves less increase in the mineral solids of the water than other methods, and has as a consequence been widely adopted during the past few years. In beginning polyphosphate treatment on old, heavily incrusted piping systems, difficulty has occasionally been experienced through the tendency of the polyphosphates to strip off the old deposits and disperse them in the water. Some care is required in the initial application to avoid complaints of turbid or red water.

B. *Galvanic Action*

As stated in Section II of this report, there is a tendency for each metal to release ions to the water in which it is immersed and this tendency is different for the different metals. This solution pressure may be expressed in terms of electrical voltage. As already noted,

the metals may be arranged in a table in order of decreasing solution pressure. Such a table is referred to as the "electrochemical" or "electromotive" series of the elements. The following series includes the metals commonly encountered in the water-works field:

*Electrochemical Series of the Elements*

| | |
|---|---|
| Aluminum | Tin |
| Chromium | Lead |
| Zinc | Hydrogen |
| Iron | Copper |
| Nickel | Silver |

When two dissimilar metals in contact with each other are immersed in water, the metal that stands higher in the series will tend to release metal ions to the solution, while hydrogen will be formed on the one lower in the series. With reference to the nomenclature used in Section II, the anodic reaction occurs on the metal higher in the series and the cathodic reaction on the one lower in the series. This results in a flow of current through the solution from the point where the metal is going into solution to the point where hydrogen is being plated out and a similar flow of current in the opposite direction across the junction of the two metals. The metal higher in the series undergoes rapid corrosion, while the corrosion rate of the metal lower in the series is negligible. The entire process is spoken of as "galvanic action." The steps in the process are influenced by the same factors that were described in Section II-A for ordinary corrosion. The extent of galvanic action is also influenced by the difference in potential between the two metals undergoing corrosion and by the relative area of the two metals. If the area of the metal lower in the series (the cathodic area) is large compared with the anodic area, corrosion will be more extensive, because there is a large area available for the discharge of the hydrogen that is formed. The extent of galvanic action is also influenced by the conductivity of the solution. In the case of soft waters of very low mineral content and therefore low conductivity, galvanic action will occur only over an area of an inch or so on either side of the junction of the dissimilar metals. With waters of high mineral content, the area of activity may extend somewhat farther.

The solution potential of alloys differs from that of pure metals

and even the processing of a metal will change the electrochemical potential of the section of metal processed. The oxides of a metal likewise have a different solution potential from the original metal. Thus mill scale has a different potential from the iron of the pipe. For these reasons, and because the use of dissimilar metals is quite common in piping systems, galvanic corrosion is quite common. However, as previously stated, the effects of galvanic action are usually limited to a small area in the vicinity of the junction of the dissimilar metals and the extent of galvanic action is minimized by all of the various factors that were pointed out under the discussion of corrosion.

Galvanic action can be kept at a minimum by using the same metal as far as possible throughout the piping system. For example, the use of brass faucets, bronze valve bodies, and brass or bronze fittings with iron piping should be avoided. Where dissimilar metals are absolutely necessary, the choice should be metals as near together in the electromotive series as possible. There have been attempts to reduce the effects of galvanic action by the insertion of a short section of non-conducting piping, such as plastic or hard-rubber piping, between sections of dissimilar metal piping. This procedure will eliminate galvanic action, but it adds materially to the cost and complexity of installation.

C. *Stray-Current Electrolysis*

Stray electric currents may produce corrosion in underground pipes. Under normal conditions only direct currents will produce such corrosion. In a direct-current railway system and in the distribution of direct-current electricity, one side of the system is grounded. If there are defective grounds or defective bonding of the rails of street-car lines, some current will find its way back to the substation or power station through the earth and, in seeking the path of least resistance, current may enter an underground pipe at one point and leave it again at another. Since the pipe at the points or areas where such stray currents leave the pipe is anodic to the earth, corrosion will occur at those points. It may be severe. The remedies consist of providing more direct paths—paths of lower resistance—back to the station. Among these remedies the following may be

noted:— (a) for street-car systems: the use of a two-trolley system, thorough bonding of the rails, the use of heavy pipe covering to serve as an insulator in the vicinity of the substation or power plant, insulation of the pipe joints, and the use of drain cables to take the current off the pipe; (b) for ground connections to water pipes: careful checking of all grounds of electric, telephone and radio systems, to see that they have no potential and therefore carry no current.

Respectfully submitted,

*(Signed)* EDWARD W. MOORE, *Chairman*
WALTON H. SEARS
LAZARUS RUBIN

## PROGRESS REPORT OF COMMITTEE ON LAYING CAST-IRON WATER MAINS

August 25, 1949

*To the Members of the New England Water Works Association:*

Your Committee on Laying Cast-Iron Water Mains has continued to coöperate with the corresponding committee of the American Water Works Association in revising the 1938 Standard Specifications for Laying Cast-Iron Pipe, which included requirements relative to both laying and disinfection.

It was hoped that a final report could be presented this year. However, extended consideration of the proposed specifications by the A. W. W. A. has made it impracticable to do so.

As reported last year, a separate document relating to the chlorination of pipe-lines and entitled "A Procedure for Disinfecting Water Mains" was published in the February, 1948, *Journal* of the A. W. W. A. Certain parts of this are being reconsidered. Revised specifications for laying pipe alone have not as yet been published.

Aside from the changes made necessary by the separation of chlorination and pipelaying, improved treatment of certain subjects, and editorial changes, there are two major topics under consideration, namely:

The elimination of hemp and jute, and incidentally other vegetable derivatives, as packing material for bell-and-spigot joints.

The omission of specifications for sulfur joint compounds for bell-and-spigot joints.

The first of these topics is included in both the specifications for laying pipe and the disinfection procedure; the second, only in the specifications for laying pipe. Brief comment on each might be helpful in eliciting observations from the membership of value to your Committee.

*Hemp and Jute.* These vegetable derivatives have long been used

in packing joints. Although they are two distinct products coming from different plants, the terms are used loosely and interchangeably.

For some years, investigators have demonstrated that these materials possess characteristics which both promote the growth of bacteria and make disinfection of the material very difficult by any available methods suitable for field use. In many cases the practical result of these characteristics has been the necessity of repeated chlorination and flushing of newly laid mains, before satisfactory bacteria counts could be obtained. Good practice now requires a bacterial analysis of the water from newly laid mains before they are put into service. It would also seem to be good practice not to use for jointing pipe any material which introduces and promotes the growth of bacteria within the pipe. The Minnesota State Board of Health has prohibited the use of jute or hemp in packing bell-and-spigot joints.

Substitute joint-packing materials of rubber, braided asbestos, and braided treated paper are now available. Until the hemp and jute industry is successful, where others have failed, and produces a satisfactory, disinfected packing material, hemp and jute and also the little-used cotton will continue to be omitted from the A. W. W. A. Specifications as satisfactory packing materials.

*Sulfur Joint Compounds.* Sulfur joint compounds have been used for a number of years as a substitute for lead. Many widely scattered communities have reported the need for extensive and costly repairs in pipe-lines jointed with sulfur compounds. In such cases, the failures usually took place in one or more of the following ways:

Cracking of pipe bells;
Corrosion of pipe bells and spigots;
Disintegration of the compound.

The causes for such failures, particularly those of the last two types, are unknown. However, the Arthur D. Little Laboratories are studying the problem for the Cast Iron Pipe Research Association.

The A. W. W. A. being an organization of national scope, it

seems proper for it to omit from a standard to be used throughout the country jointing materials which appear to have been unsatisfactory in many localities, pending determination of the causes. Our Association, however, may adopt a different policy. Unless it can be demonstrated that there have been numerous failures of sulfur compounds in the New England area, it would be unwise to omit such material from a specification for laying cast-iron water mains.

*Comments Welcomed.* So that it may have the benefit of the thought and experience of members of this Association in preparing its final report, your Committee will welcome comments on the sterilization and use of hemp, jute and cotton. It will also be particularly glad to receive comments and reports of experience with the sulfur compounds.

Respectfully submitted,

*(Signed)* W. S. MARINER, *Chairman*
GEORGE W. COFFIN

## REPORT OF HYDRANT SPECIFICATION COMMITTEE

*To the New England Water Works Association:*

The Hydrant Specification Committee of this Association is not ready to make a final report at this time. We can only report progress.

As this Committee is working in connection with the American Water Works Association Hydrant Specification Committee, we feel that this matter should be worked out jointly and it is quite apparent, with the progress that is being made, that a final report can be made sometime during the year 1950.

Respectfully submitted,

*(Signed)* ROGER W. ESTY, *Chairman*
HARRY U. FULLER
H. W. GRISWOLD

## FINAL REPORT OF COMMITTEE ON METER SPECIFICATIONS

*To the Members of the New England Waters Works Association:*

This Committee, originally appointed in 1938 by George A. Sampson, President, to coöperate with a similar committee of the American Water Works Association, has, from time to time, made progress reports in which details of the Committee's endeavors have been outlined.

Five separate specifications have been developed, to include the various types of meters normally used in the sale of water for domestic, mercantile and industrial use.

The Specification for Displacement Meters was published in the December, 1942, JOURNAL of the New England Water Works Association and was accepted as a tentative specification on March 15, 1943. Tentative Standard Specifications for Current, Compound and Fire-Service Type Meters were published in the September, 1947, JOURNAL. These specifications have all been advanced to standard status by the American Water Works Association.

Other than to adopt the Displacement Meter Specification on a tentative basis, no formal action has been taken on same by the New England Water Works Association.

A new specification for Current Type, Propeller Driven, Meters has been developed and approved by the Committee during the current year. This Specification, approved as tentative by the American Water Works Association Board of Directors on July 21, 1949, will be published in the New England Water Works JOURNAL in the near future.

It is the recommendation of your Meter Committee that, subsequent to publication of this most recent Specification, the Association, after due notice to the membership, consider the adoption of all five Specifications as standards of the Association.

As the work of this Committee now appears to be complete,

it is further recommended that, after adoption of the specifications, the Committee be discharged.

Respectfully submitted,

*(Signed)* RICHARD H. ELLIS, *Chairman*
WARREN A. GENTNER
DWIGHT H. HALL

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*Tentative*

# STANDARD SPECIFICATIONS

*for*

# COLD-WATER METERS—CURRENT TYPE PROPELLER DRIVEN

These "Tentative Standard Specifications for Cold-Water Meters—Current Type—Propeller Driven" are based upon the best known experience and are intended for use under normal conditions. They are not designed for unqualified use under all conditions and the advisability of use of the material herein specified for any installation must be subjected to review by the engineer responsible for the installation in the particular locality concerned.

**American Water Works Association**

Approved as Tentative by the Board of Directors of the A.W.W.A. on July 21, 1949

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AMERICAN WATER WORKS ASSOCIATION

*Second Printing, September 1949*

**AMERICAN WATER WORKS ASSOCIATION**
***Incorporated***
**500 Fifth Avenue, New York 18, N.Y.**

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## Committee Personnel


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*N.E.W.W.A. Representatives*

R. H. ELLIS
W. A. GENTNER
D. H. HALL

*Tentative*

# Standard Specifications for Cold-Water Meters Current Type—Propeller Driven

## Section 5–1—General

### Sec. 5–1.1—Scope

*These specifications embrace the various classes of propeller-driven, cold-water current meters for water works main and branch line (2-in. and larger) service and cover the materials and workmanship employed in their fabrication.*

### Sec. 5–1.2—Kind and Type

The kinds of meters covered are propeller-driven, main and branch line meters of the current or velocity type. These meters register the flow by recording the revolutions of a propeller which is set in motion by the force of the flowing water coming in contact with the propeller blades.

## Section 5–2—Capacity, Size and Length

### Sec. 5–2.1—Capacity

Capacity or delivery classification shall be the maximum quantity given in Table 1, Column 3.

Meters shall have a loss of head at maximum capacity not exceeding the value tabulated in Table 1, Column 2.

### Sec. 5–2.2—Size

The size of the meter given in Table 1, Column 1, shall be in terms of the nominal size of the opening in the inlet and outlet flanges or the bell-and-spigot ends of the meters.

### Sec. 5–2.3—Length

The minimum and maximum overall lengths of the meter, face to face of spuds or flanges—or the laying lengths of bell-and-spigot meters—are given in Table 2, Columns 2 to 7, inclusive. A filler piece can be inserted to increase the length of the shorter meter, if required, but the meter itself must not be shorter than the minimum length given in the table.

## Section 5–3—Design

### Sec. 5–3.1—Cases or Meter Bodies

The outer case or meter body shall be of cast iron protected by a corrosion-resistant coating, or of bronze or other suitable corrosion-resistant material, and meters shall be equipped with built-in straightening vanes. Casting shall not be repaired, plugged, brazed or "burned in."

All meters shall have the size, serial number and direction of the flow through the meter properly indicated. Meters shall be designed for easy removal of the operating mechanism without disturbing the connections to the pipeline.

### Sec. 5–3.2—External Bolts

All external bolts and washers shall be of nonferrous material or protec-

tively treated iron or steel. (All external cap screws or studs shall be of bronze, monel metal or stainless steel.) Nuts shall be of nonferrous material and shall be designed for easy removal after long service.

**Sec. 5–3.3—Connections**

Meter body connections may be threaded, flanged or bell and spigot, as required. (Threaded connections shall have American Standard internal-taper pipe threads, [ASA 132.1–1941]). Flanges shall be of the round type, faced and drilled, and shall conform to the American Standard cast-iron pipe flange, Class 125 (ASA B16a–1939) for diameter drilling and thickness. Bell-and-spigot connections shall be of cast iron and shall conform to the American Standard cast-iron pit-cast pipe (ASA A21.2–1939), *as far as the specifications apply.*

**Sec. 5–3.4—Registers**

Registers shall indicate in cubic feet, gallons or other units of measure and shall have at least six number wheels.

The figures on the number wheels shall be large and distinct so that they can be read easily. The register lock and side gears shall be securely fastened to their number wheel discs and hubs. The tumbler pinions shall mesh accurately at the turnover points with the lock and side gears of the adjacent number wheels. Both main and pinion shafts shall be so secured in the register frame that they cannot get out of position. The pinion shaft shall be so designed that there is no possibility of its bending and allowing the pinion to skip at the turnover point. All parts of the register shall be plated or given a protective treatment, or shall be made of material as nearly noncorrosive as possible.

The minimum indication of the digits appearing on the first number wheel, when indicating cubic feet, shall be as given in Table 2, Column 8, and, when indicating gallons, shall be as given in Column 9.

The manufacturer must be able to furnish initial dial indication values equal to ten times those listed in Table 2, Columns 8 and 9, when required.

There shall be a test index circle which shall be divided into ten equal parts. The hand or pointer shall taper to a sharp point and shall be accurately set and securely held in place.

TABLE 1

*Propeller-driven Current Meters*

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Meter Size *in.* | Maximum Loss of Head *psi.* | Normal Range of Flow *gpm.* | Maximum Speed of Propeller *revolutions per cu.ft.* |
| 2 | 1.50 | 15– 80 | 75.00 |
| 3 | 1.10 | 30– 200 | 35.00 |
| 4 | 1.00 | 45– 400 | 22.00 |
| 5 | 0.90 | 75– 600 | 15.00 |
| 6 | 0.85 | 90– 900 | 6.00 |
| 8 | 0.45 | 100– 1,200 | 2.80 |
| 10 | 0.35 | 125– 1,500 | 1.80 |
| 12 | 0.25 | 150– 2,000 | 1.20 |
| 14 | 0.22 | 250– 2,500 | 0.60 |
| 16 | 0.20 | 275– 3,500 | 0.40 |
| 18 | 0.19 | 400– 4,500 | 0.35 |
| 20 | 0.18 | 475– 5,500 | 0.25 |
| 24 | 0.17 | 700– 8,000 | 0.10 |
| 30 | 0.16 | 1,200–12,000 | 0.07 |
| 36 | 0.15 | 1,500–16,000 | 0.05 |

**Sec. 5–3.5—Register Boxes**

Register boxes or bonnets shall be made of cast iron protected by a non-

corrosive treatment, or of bronze composition, aluminum or molded plastic.

Window glasses, if used, shall be inserted from the inside and shall be securely held in place without the use of putty or pins. All register compartments shall be provided with a water escape hole $\frac{1}{8}$ in. in diameter, unless proper provision has been made in the cover below the register bottom plate.

shall fully mesh with each other and shall run freely. Bearings shall be secured so that they will not work out of place and shall be readily replaceable.

### Sec. 5–3.7—Operating Mechanism

The operating mechanism from propeller to output shaft shall be easily removable as a complete assembly from the meter body.

Propeller shafts shall revolve in re-

TABLE 2

*Propeller-driven Current Meters*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| Meter Size *in.* | Meter Length—*in.* | | | | | | Minimum Indication of Initial Dial | |
| | Screw Tube | | Flanged Tube | | Bell-&-Spigot Tube | | *cu.ft.* | *gal.* |
| | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum | | |
| 2 | 11 3/8 | 14 | 13 1/4 | 14 | | | 1 | 10 |
| 3 | 11 3/4 | 16 | 12 1/4 | 16 | | | 1 | 10 |
| 4 | 11 3/4 | 18 | 13 1/4 | 18 | 21 1/2 | 21 1/4 | 1 | 10 |
| 5 | 15 | 20 | 15 1/4 | 20 | | | 1 | 10 |
| 6 | 18 | 24 | 22 | 22 | 25 1/2 | 27 | 10 | 100 |
| 8 | | | 24 | 24 | 28 | 32 | 10 | 100 |
| 10 | | | 26 | 26 | 30 | 34 | 10 | 100 |
| 12 | | | 28 | 28 | 32 | 36 | 10 | 100 |
| 14 | | | 39 | 42 | 43 | 50 1/2 | 100 | 1,000 |
| 16 | | | 42 | 48 | 46 | 56 | 100 | 1,000 |
| 18 | | | 45 | 54 | 49 | 62 1/2 | 100 | 1,000 |
| 20 | | | 48 | 60 | 52 | 68 | 100 | 1,000 |
| 24 | | | 54 | 72 | 58 | 80 | 100 | 1,000 |
| 30 | | | 63 | 84 | 67 | 93 1/2 | 100 | 1,000 |
| 36 | | | 72 | 96 | 76 | 105 1/2 | 100 | 1,000 |

### Sec. 5–3.6—Intermediate Gear Trains

Intermediate gear trains may be mounted on the measuring chambers or in the upper main casings. Gear train frames, spindles, gears, pinions and bearings shall be made of durable, corrosion-resistant material. Pinions and spur gears shall be firmly fastened, movable, corrosion-proof ball or roller bearings or in bushings of durable material.

### Sec. 5–3.8—Propellers

The measuring propellers shall be made of suitable molded or cast material. The measuring propeller shall be mounted or shall rotate on phosphor-

bronze or some other suitable metal spindle and shall be supported by jewel, ball or other suitable bearings. Measuring propellers mounted on spindles shall revolve in corrosion-proof ball or roller bearings or in bushing of durable material. The measuring propeller, together with its spindle, shall be, as nearly as practical, of the same specific gravity as water.

The number of propeller revolutions per cubic foot should not exceed the quantities given in Table 1, Column 4.

### Sec. 5–3.9—Seal Wire Holes

Register box screws shall be drilled for seal wire holes. All seal wire holes shall be not less than $\frac{3}{32}$ in. in diameter.

## Section 5–4—Registration

The registration on the meter dial shall indicate the quantity recorded to be not less than 98 per cent nor more than 102 per cent of the water actually passed through the meter while it is being tested at any rate of flow within the limits specified in Table 1, Column 3, under "Normal Range of Flow."

## Section 5–5—Pressure Test

Meters shall be guaranteed to operate under a working pressure of 150 psi. without leakage or damage to any part.

## Section 5–6—Workmanship and Materials

Meters shall be guaranteed against defects in materials and workmanship for a period of one year from the date of shipment. Parts to replace those in which a defect has developed within such period shall be supplied without charge, piece for piece, upon the return of such defective parts to the manufacturer thereof or upon proper proof of such defect.

## Section 5–7—Rejected Meters

The manufacturer shall, at his own expense, replace or satisfactorily readjust all meters rejected for failure to comply with these specifications.

## NOTES

*These notes are not part of the specifications. They are given only as information concerning the testing and care of meters and important materials used in meter construction. They are not intended to limit in any way the future development of better materials for general use or the use of special metals with specific waters which may require materials of different composition to give service equal to that recorded in normal practice.*

(1) *Tests*

Capacity tests are those which test the design of the meter. When a meter of a given design has once been tested for capacity, it should not be necessary to test this type of meter again unless a change has been made in the design.

Registration tests are those which test the assembly and workmanship of the meter. Each meter should be tested for registration, as there is no assurance that, because one meter of a given design is within certain limits of accuracy, all meters of this design will necessarily give similar results. The register furnished

with each meter should be used by both the manufacturer and the purchaser in making registration tests.

All meters should be tested for accuracy of registration within, and as near as practicable to, the low and high rates given under Table 1, Column 3, "Normal Range of Flow," and occasionally additional tests should be made at one or more intermediate points.

A pressure test should be made on each size of meter of a particular design furnished. The pressure is to be 150 psi., and may be obtained by the use of a hand pump or any other method available. The meter should be tested for accuracy before and after it has been tested by static pressure, to determine whether there has been any distortion that would affect the registration. It is unnecessary to make more than one pressure test on each size of a given design if satisfactory results are obtained. A working-pressure test is preferable to a static-pressure test.

If the purchaser has no testing equipment, a certificate should be furnished by the manufacturer showing that each meter has been tested for accuracy of registration, that it complies with the specifications and that the size and design meet with the capacity requirements.

(2) *Testing Equipment*

Typical test equipment includes:

(a) A valve on the supply line which would permit the starting and stopping of the flow without appreciable loss of time. This valve should be wide open during test.

(b) A valve or other suitable device on the discharge line which can provide the rate of flow desired.

(c) Pressure gages on supply and discharge pipes, so that any change in pressure which would affect the rate of flow can be detected. The discharge pipe must be under sufficient head to guarantee a pressure on the outlet of the meter.

(d) A measuring device of either the volumetric or weighing type. The accuracy of the determination of the amount of water discharged should be such as to bring the limit of error within 0.25 per cent. The amount of water passed should be sufficient to cause at least one revolution of the pointer on the initial dial except for the test at the minimum flow rate. The amount passed at this rate should be of sufficient quantity to secure a true indication of the accuracy.

(e) A differential mercury manometer (or inverted water manometer with an adjustable scale for precision reading in capacity tests). The inlet connection to the manometer should be made at a point about one-half a pipe diameter ahead of the inlet edge of the meter body, and the outlet connection about two pipe diameters beyond the outlet edge of the meter body. These connections should be at right angles to the axis of the pipe and should be filed or ground off until they are smooth and flush with the inside surface of the pipe; they should be free from any burrs. The size of the connections should not exceed ¼ in. for 2- or 3-in. meters; ⅜ in. for 4-, 5- and 6-in. meters; and ½ in. for 8-in. and larger meters. The taps are connected to the manometer by rubber or metallic tubing. Provision is to be made for the complete removal of air from the manometer and the tubing connected therewith, and the installation is to be such that air will rise to the air outlets. For accurate observations it is necessary to read both sides of the mercury column simultaneously in order to compensate for irregularities in the diameter of the manometer tubes and to avoid errors due to fluctuations.

(3) *Care of Meters*

In this type of current meter the motion of the propeller is transmitted by a system of gearing to the register, where the flow is recorded in convenient units of measure, such as cubic feet or gallons. The gearing serves to translate the motion of the propeller into the unit of measure indicated by the register. The register is at all times a measure of the number of revolutions of the measuring

propeller in terms of cubic feet or gallons. It records a true measure of flow only when the meter has been properly calibrated by gear adjustment, and after proper calibration will continue to register correctly only as long as the propeller continues to make the proper number of cycles for each unit of quantity passed through the meter. If, after calibration, any condition should develop whereby the propeller is compelled to make less than the proper number of cycles per unit of quantity passed through it, the meter will underregister. If the propeller is compelled to make more than the proper number of cycles, the meter will overregister. The proper number of cycles is the number made at the time the meter is calibrated.

Meters may be installed in horizontal, vertical or slanting pipelines. Both the piping on the inlet side of the meter and the meter itself must run absolutely full of water at all times. The register may face upward or sideways, but not downward without a special arrangement to prevent flooding of the register and register box or bonnet by accidental leakage through the stuffing gland.

Under ordinary working conditions, there are a number of factors that may cause under- or overregistration after comparatively short intervals. The more important of these factors, which should be guarded against to secure proper registration, are:

(a) *Excessive wear.* Excessive wear of the moving parts of the meter may be caused by improper setting, by overspeeding, or, in general, by the selection of a meter too small for the work required. The effect of excessive wear of the propeller or measuring chamber is slippage and underregistration. Excessive wear of the intermediate gear train may cause binding of the gears or gear slippage. In any case, if the meter is not stopped entirely, underregistration will result. To avoid excessive wear, meters should not be run at destructive speeds. The capacity of the meters given in the specifications is for continuous 24-hour service. The maximum rate of flow which should be passed through the meters for very short periods of time or the peak loads which should come upon meters only at long intervals should never exceed twice the tabulated values.

(b) *Temperatures.* High temperatures may cause distortion of the propeller blades, bearing troubles and so on. The result will be incorrect registration or failure of the meter. Low temperatures, above 32°F., have no noticeable effect on the working parts of the meter. Freezing will stop the meter and possibly damage it.

Cold-water meters are not affected by temperatures up to about 80°F. If this temperature may be exceeded, the manufacturer should be consulted with respect to special provisions for the higher temperature and the resultant effect on accuracy and capacity.

To avoid troubles caused by temperature, meters should be set at locations where they will be protected from heat and frost. At locations where hot water from heating systems may be forced back through the meter, a check valve and pressure and temperature relief valve should be installed on the outlet side of the meter, if the manufacturer requires it.

(c) *Corrosion.* The metals used in the construction of a meter may be affected by the corrosive action of water. The action is very slow with most potable waters. The result is that parts of the meter are weakened, particularly the teeth of the open intermediate gears, and, in meters that are idle for long intervals, there is a tendency toward binding. Tuberculation of the outer case in meters of the current type may change the normal direction of flow and cause overregistration.

(d) *Material in suspension.* Foreign material carried in suspension may be deposited, and accumulations of deposit always tend to cause overregistration, as any conditions tending to change the velocity of flow, after the meter has been

calibrated, will cause overregistration. Such overregistration is not limited.

Meters provided with strainers will retain the larger particles of material in suspension, but the strainer will soon become clogged if the water is not kept reasonably free of suspended matter. Sand is especially destructive and care should be exercised to keep sand from reaching the pipes supplying the meters.

Because the finer particles of suspended material cannot be prevented from reaching the meter, troubles from this source can be avoided only by cleaning the meter periodically, the interval between cleanings depending upon the quality of the water.

(e) *Periodic tests.* Meters properly selected as to size and type will give satisfactory service over a long period without attention only when operated under ideal conditions. Under ordinary conditions, meters must be given some care if they are to function properly. Usually it is impossible to ascertain, without an actual test, whether a meter which has been in service is registering within the required degree of accuracy. Consequently, to insure reliable meter measurements, it is essential that all meters be subjected to periodic tests. The interval between tests and the method of conducting them must be governed largely by local conditions. Under *average* conditions, the meters should be overhauled and checked at least once every two years. Observations made during the first year of operation will determine how often the approach and propeller sections of the waterway must be cleaned of incrustations to prevent overregistration.

Many state regulatory commissions specify the intervals between the tests on both a time and quantity basis.

Meters of the current type, used for measuring unfiltered surface waters, should be cleaned about once a year, in order that they may be kept in good working condition. When filtered or exceptionally clean water is used, the interval between cleanings may be longer.

The best results will be obtained from current meters if they are calibrated in place, since the accuracy of the meter may be affected by changes in the distribution of velocities approaching the meter. A meter of this type, calibrated where there is a straight run of pipe and no swirling flow on the inlet side of the meter, may register incorrectly from the start if installed where there is a bend, valve or any piping arrangement producing helical motion in the flow near the inlet side. Straightening vanes built into the meters appreciably reduce errors due to helical flow or other disturbances. Any other conditions tending to change the distribution of velocities existing at the time of calibration may affect the accuracy of the meter. If calibrated on the premises, this source of error is minimized.

Following the manufacturer's recommendation is the best way to produce an installation which will minimize the probability of affecting the accuracy of the meter as determined by laboratory test.

For 3-in. and larger meters the installation of a test tee in the outlet piping makes testing easier and reduces the cost of testing on the premises.

(4) *Bronze*

A bronze satisfactory for most water is that of A.S.T.M. Specifications B62–36 or No. 2 Federal Specifications QQ–B–691a for an alloy of copper, tin, lead and zinc, known commercially as composition metal, 85–5–5–5, ounce metal, red brass or hydraulic bronze.

(5) *Rubber*

A satisfactory rubber for propellers and bushings should, among other items, have a specific gravity under 1.2, a minimum tensile strength of 6,500 psi., a maximum elongation of 5 per cent, a hardness (scleroscope test) of not less than 67, a free-sulfur content of 3 per cent or less, a free-ash content of not more than 3 per cent and a uniformity of cure and physical characteristics.

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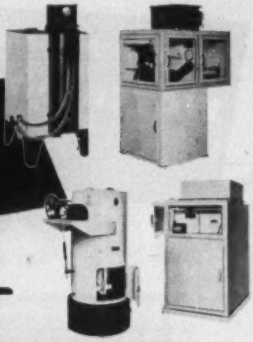

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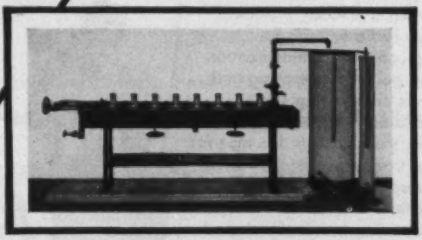

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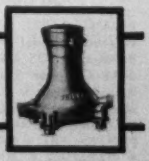

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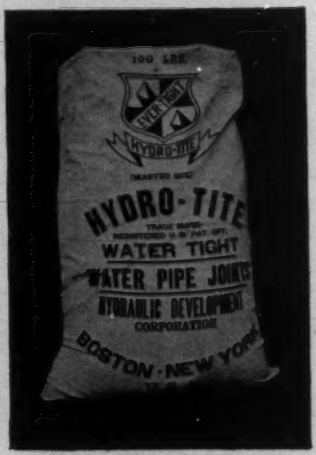


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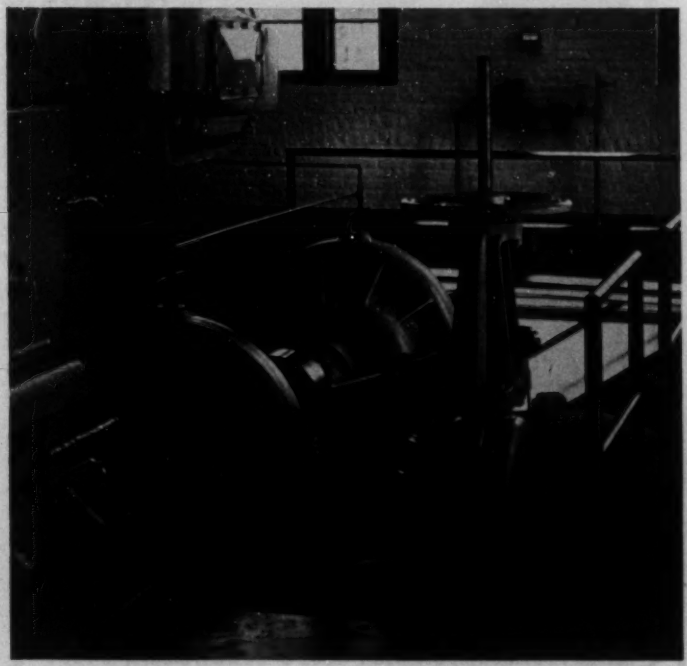

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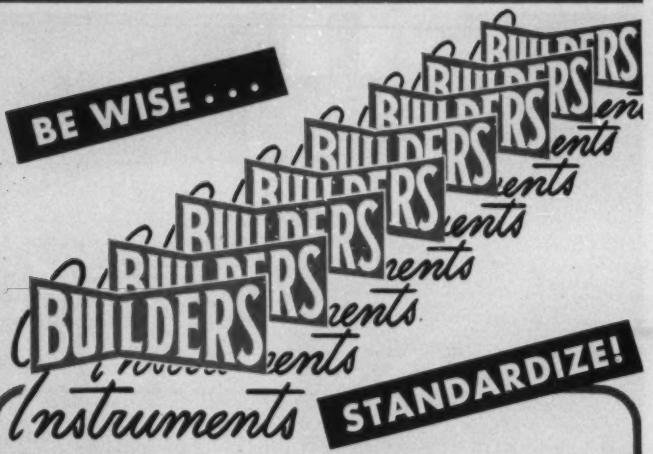


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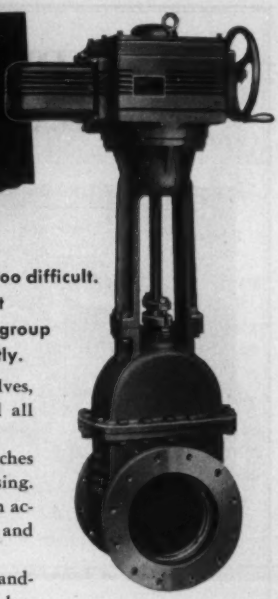

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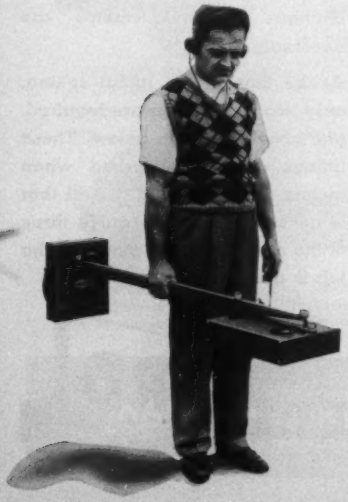

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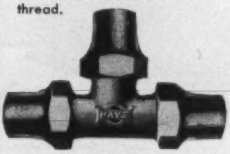

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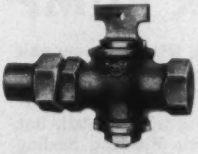

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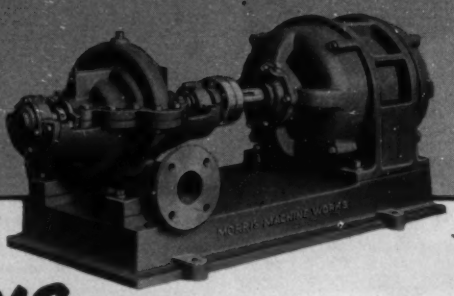


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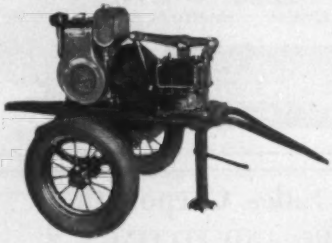

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ALSO

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# CAST IRON PIPE

*Flanged Pipe* *Flexible Joint Pipe*

*Bell and Spigot Pipe*

*Special Castings* *Short Body B. & S. Specials*

*Warren* (WF) *Spun Centrifugally Cast Iron Pipe*

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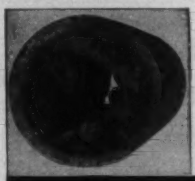

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The most practical way to meet today's overload demand is to clean clogged water mains. FLEXIBLE Underground Pipe Cleaning Co., specializes in such jobs— any size—2" to 72".

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*New England Representative*

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**My 8-9023**
**My 8-9024**

# 1879—ROSS— 1879

## AUTOMATIC VALVES

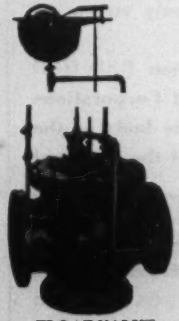
Controls elevation of water in tanks, basins and reservoirs

ALTITUDE VALVE
1. Single Acting
2. Double Acting

Maintains desired discharge pressure regardless of change in rate of flow

REDUCING VALVE

Regulates pressures in gravity and pump systems; between reservoirs and zones of different pressures, etc.



Maintains levels in tank, reservoir or basin

1. As direct acting

2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.

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A self contained unit, with controls three or more automatic

COMBINATION VALVE

Combination automatic control both directions through the valve.

Maintains safe operating pressures for conduits, distribution and pump discharge

SURGE-RELIEF VALVE

Electric remote control—solenoid or motor can be furnished

REMOTE CONTROL VALVE

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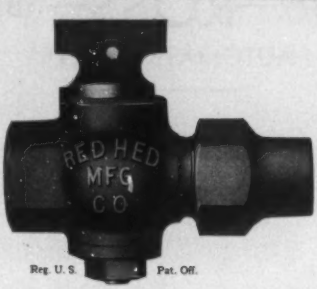


Fig. 408

**RED HED Copper to Iron Stop — One Nut**

**RED HED CORPORATIONS FOR COPPER SERVICE TUBE**

HAND GROUND—HEAVY PATTERN—SOLID PLUGS (EXCEPT WATERWAY)
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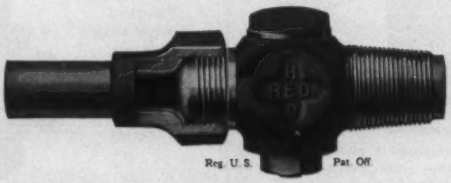


Fig. 438 Corporation and Compression Nut 438-A

**Renewing or repairing brass goods under costly streets or roads is expensive and annoying.**

**Freedom from such trouble can be avoided when RED HED brass goods are used. All RED HED Stops and Corporations are made with *hand ground plugs* lapped to the body of the Stop or Corporation, insuring ease of turning of the plug and freedom from leakage.**

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***Makers of***

**High Grade Brass Goods for Water Works**

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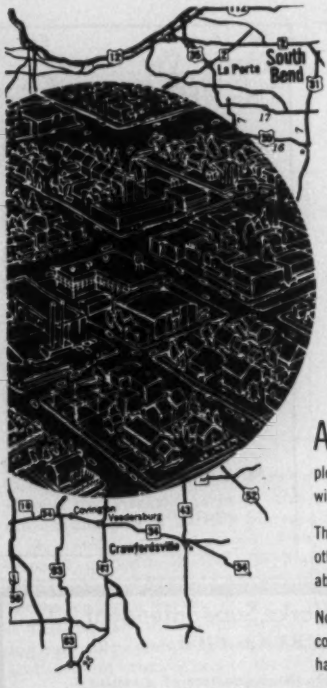


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A typical industrial city, with an especially difficult water problem, Whiting, Indiana, will soon complete its 10th year of successful taste and odor control with Ozone.

This Welsbach-Ozone system was installed after all other attempted methods failed to produce a palatable water.

Now, after a decade of actual experience with Ozone, consumers and officials alike agree that the problem has been overcome.

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If taste, color or odor are involved in your city's water problems, Ozone may be the effective, economical answer. Your inquiry to The Welsbach Corporation will bring you prompt information without obligation on your part.

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*OZONE PROCESSES DIVISION*

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**100 WHAMS PER MINUTE**

**RIGHT ON THE JOINT**

**X 15 HOURS = 90,000 KNOCK-OUT BLOWS**

LINE jointed with Tegul-MINERALEAD. 90 lbs. water pressure maintained. 50 lb. power hammer, engine-actuated, rigged to pound joint for 15 hours straight. Test ended with nary a sign of a leak. Nice going—eh? Do you wonder we call

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**The *Superior* Jointing Compound for Bell & Spigot Pipe.**

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**CEMENT LINED SERVICE PIPE:—**

**Resists Corrosion**

**Has proven practical for nearly three-quarters of a century**

Immediate delivery can be made to waterworks on both wrought iron and steel, black or galvanized.

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**EUREKA PIPE COMPANY, Inc.**

**Manufacturers of CENTRIFUGAL CEMENT LINED PIPE and LEAD AND TIN LINED FITTINGS**

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*Positive Operation*

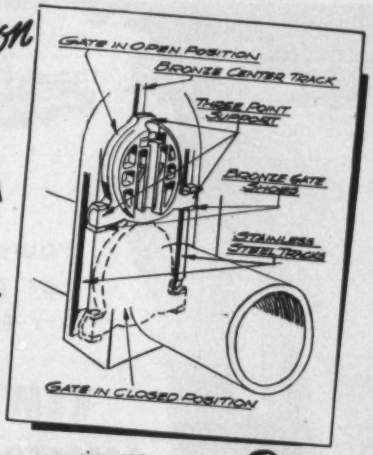
RENSSELAER

**SQUARE BOTTOM GATE VALVES**

*have 3-point gate support*

moving on

**STAINLESS STEEL TRACKS**




Designed for longer life under severe operating conditions, this was the pioneer valve supporting the downstream gate in THREE places at EVERY point in its travel. In its full length of travel this gate is smoothly guided by the lower supporting lugs sliding on STAINLESS STEEL TRACKS. The center track, for the top lug, is bronze.

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● *Without obligation on your part, a Rensselaer representative will be glad to give you the benefit of his experience in Valves, Hydrants and other Rensselaer products. Call our nearest office.*

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1—*Valve closes easily under high differential head.*
2—*Valve operates frequently without excessive wear.*
3—*Valve can be used for throttling without damaging seat rings.*
4—*The gates are properly supported for operating in vertical lines.*

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RENSSELAER

*Gate Valves • Square Bottom Valves • Tapping Valves and Sleeves*
*Hydrants • Check Valves • Air Release Valves*

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*Division of Neptune Meter Company*

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"QUICK EXECUTION OF THE JOB WAS ESSENTIAL"

# K&M "CENTURY" ASBESTOS-CEMENT PIPE

# DID IT GOOD 'N' FAST!

Gatlinburg, Tennessee, is the "Gateway to the Great Smoky Mountains." Much local and regional trade depends on tourist traffic. The use of K&M "Century" Asbestos-Cement Pipe for the new water mains resulted in a minimum of obstruction to travel and business during installation.

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*Keasbey & Mattison has made it serve mankind since 1873*

**KEASBEY & MATTISON**

**COMPANY • AMBLER • PENNSYLVANIA**

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# 96%

## ARE
## STILL IN SERVICE

**We are stating a fact and you don't have to take our word for it. We refer you to one of the most important fact-finding jobs ever undertaken by the water works industry — the recently completed survey of the service life of water works facilities. This survey was sponsored by three water works associations.**

**The survey shows that 96% of all the cast iron water mains ever laid by 25 representative cities in sizes 6-inch and larger *are still in service.***

**A detailed report of the survey has recently been published by the American Water Works Association. We have reprinted, by permission, the facts pertaining to cast iron water mains in a brochure which will be sent on request. Write to Cast Iron Pipe Research Association, Thomas F. Wolfe, Engineer, 122 South Michigan Ave., Chicago 3, Ill.**

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*Painted for U. S. Pipe & Foundry Co. by Paul Laune*

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FOR WATER, GAS, SEWERAGE AND INDUSTRIAL SERVICE

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# New England Water Works Association

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The true value of LEADITE is best indicated by the fact that it has been used on THOUSANDS OF MILES of Water Mains,—all over this Country, as well as in many Overseas Countries.

The Pioneer self-caulking material for c. i. pipe,
Tested and used for over 40 years,
Saves at least 75%.

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